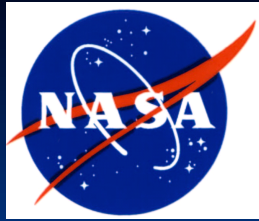


# N2NA Pylon Overheat Mishap

## When All the Ducks Line Up



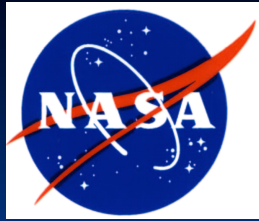
Bart Henwood  
Board Chairperson  
1 Dec 07



## N2NA Pylon Overheat Mishap

# Overview

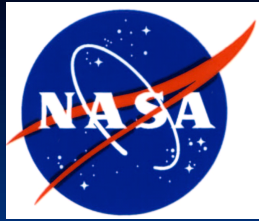
- Investigation Process
- Bottom Line
- Event Description / Damage
- Causal Tree Analysis
- Significant Observations
- Major Recommendations



N2NA Pylon  
Overheat Mishap

## Board Membership

- **Safety Rep** – Provides safety assessment and advice for board members
- **Pilot Rep** – functional specialty
- **Maintenance Rep** – functional specialty
- **Human Factors Rep** – functional specialty
- **Ex-officio** – ensures process and final report adhere to NASA standards



N2NA Pylon  
Overheat Mishap

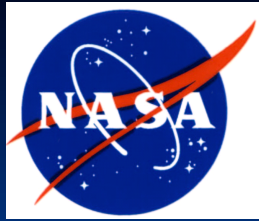
## Advisors

- Quality Rep – functional specialty
- Legal\* - handles legal issues
- Export Control\*
- Public Affairs\* - manages PA issues

All ensure final document is appropriately annotated for the type of material and is accurate

\* Required by NASA standards

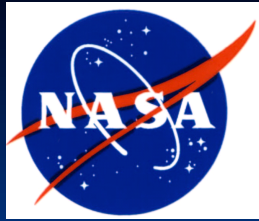




N2NA Pylon  
Overheat Mishap

## Investigation Process

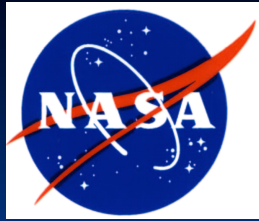
- Appointed by letter
- Trained in investigation
- 75 working days to deliver report to appointing authority
- Expected to release immediately information having safety impact



N2NA Pylon  
Overheat Mishap

## Investigation Process

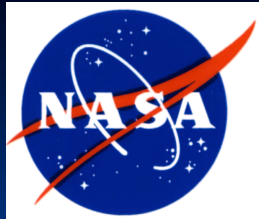
- Find Root and Proximate Cause
- Make Recommendations for Root and Proximate causes



N2NA Pylon  
Overheat Mishap

## Investigation Process

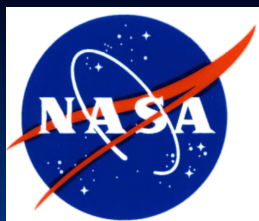
- **Proximate Cause:** The event(s) that occurred, including any condition(s) that existed immediately before the undesired outcome, directly resulted in its occurrence and, if eliminated or modified, would have prevented the undesired outcome. Also known as the direct cause(s).
- **Root Causes:** One of multiple factors (events, conditions, that are organizational factors) that contributed to or created the proximate cause and subsequent undesired outcome and, if eliminated or modified, would have prevented the undesired outcome. Typically, multiple root causes contribute to an undesired outcome.



N2NA Pylon  
Overheat Mishap

## Investigation Process

- Contributing Factors: An event or condition that may have contributed to the occurrence of an undesired outcome but, if eliminated or modified, would not by itself have prevented the occurrence.

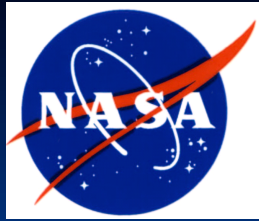


# N2NA Pylon Overheat Mishap

## Chronology of Events





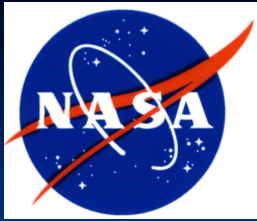


# Damage

N2NA Pylon  
Overheat Mishap



Right Pylon Panels Found Buckled

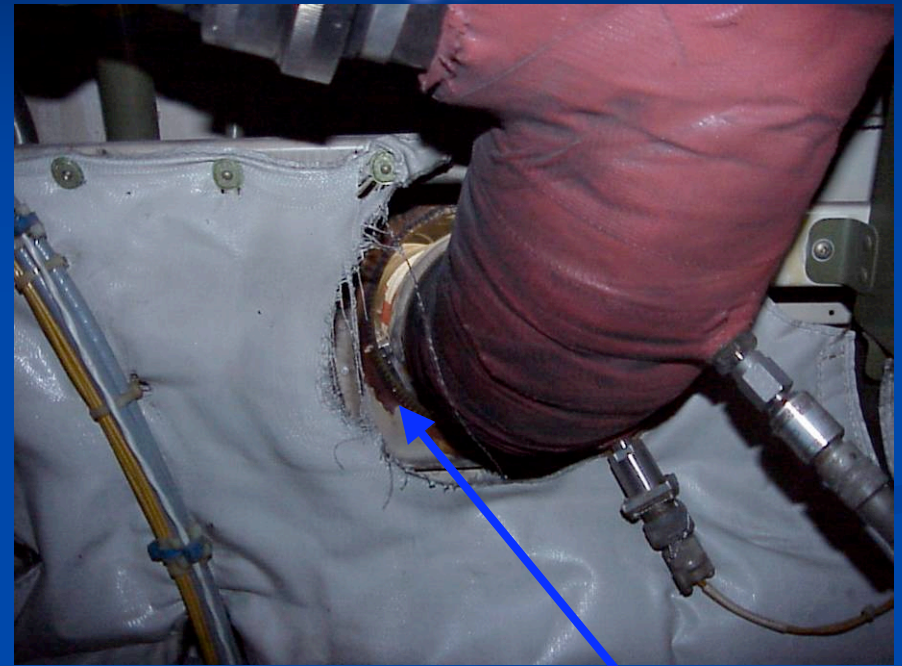


# Damage

**N2NA Pylon  
Overheat Mishap**

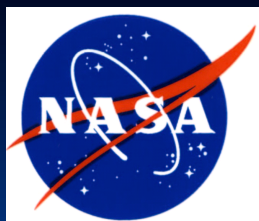


Evidence of possible Forward and Aft  
Engine mount isolator heat damage



Aft Equipment Bay Heat Damage

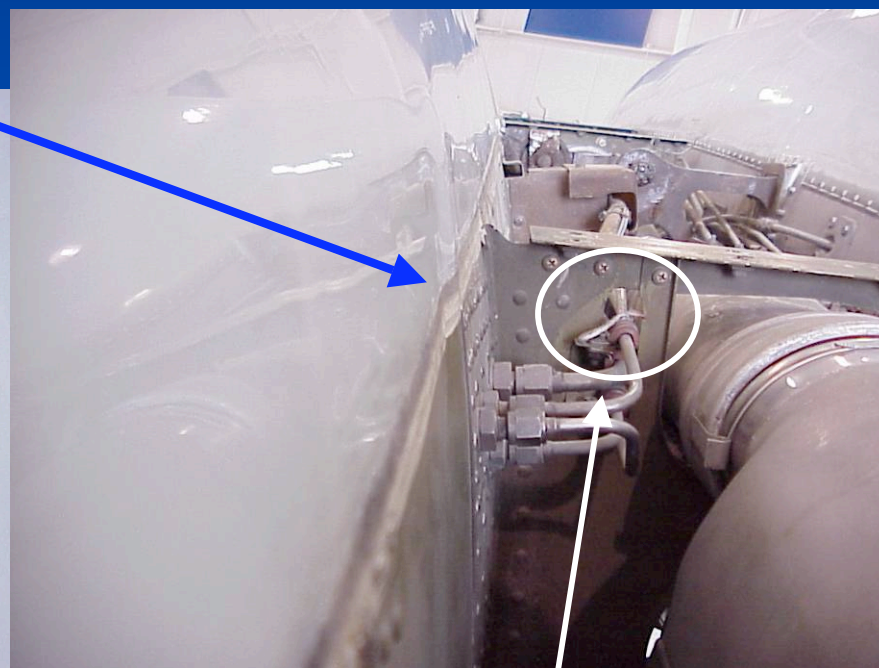
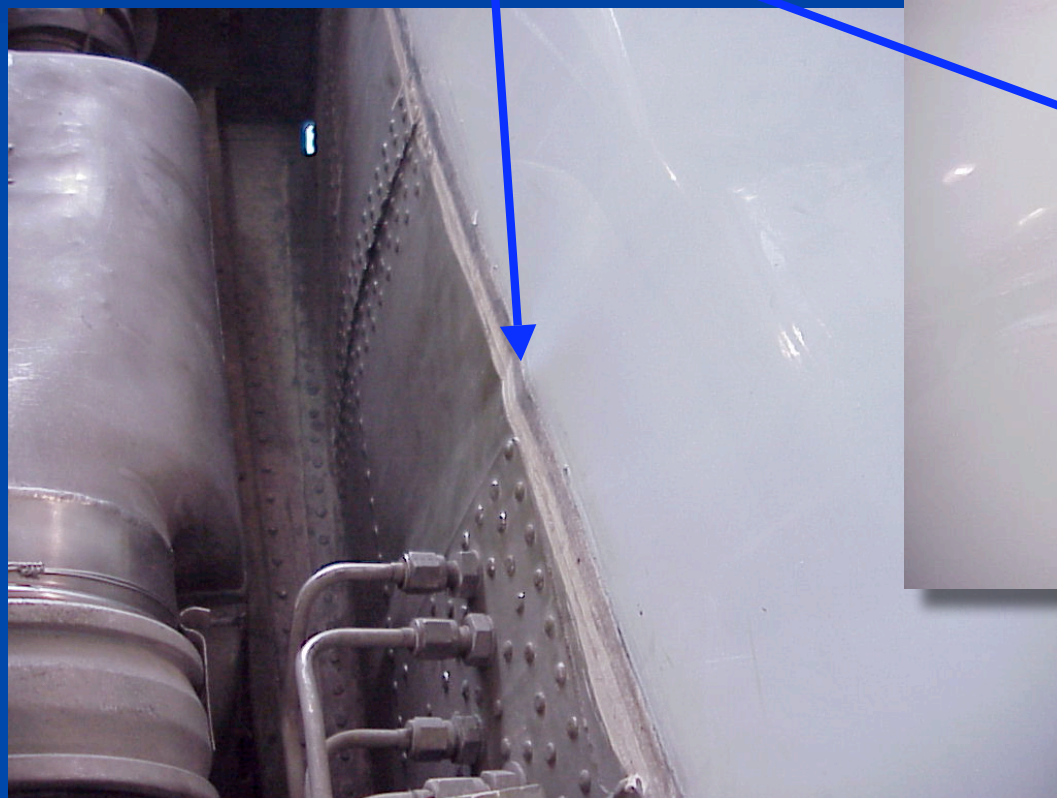




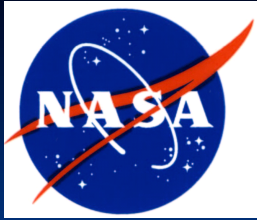
# Damage

N2NA Pylon  
Overheat Mishap

Fuselage Skin Buckled

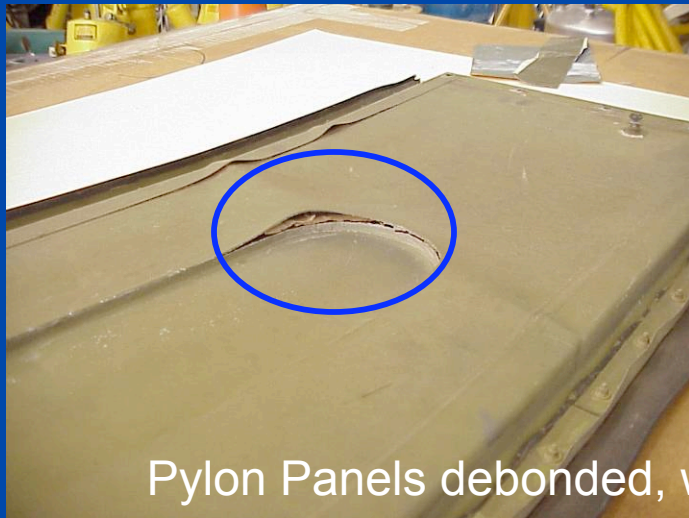
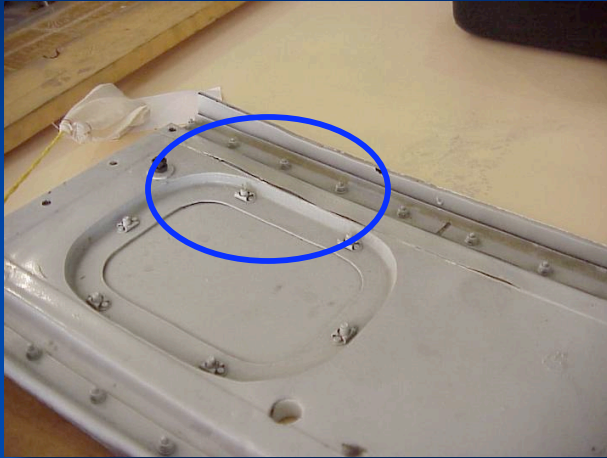


Pylon Hot Sensor Wire



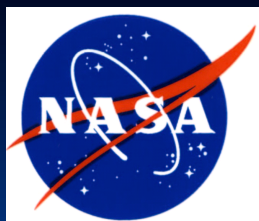
# Damage

N2NA Pylon  
Overheat Mishap



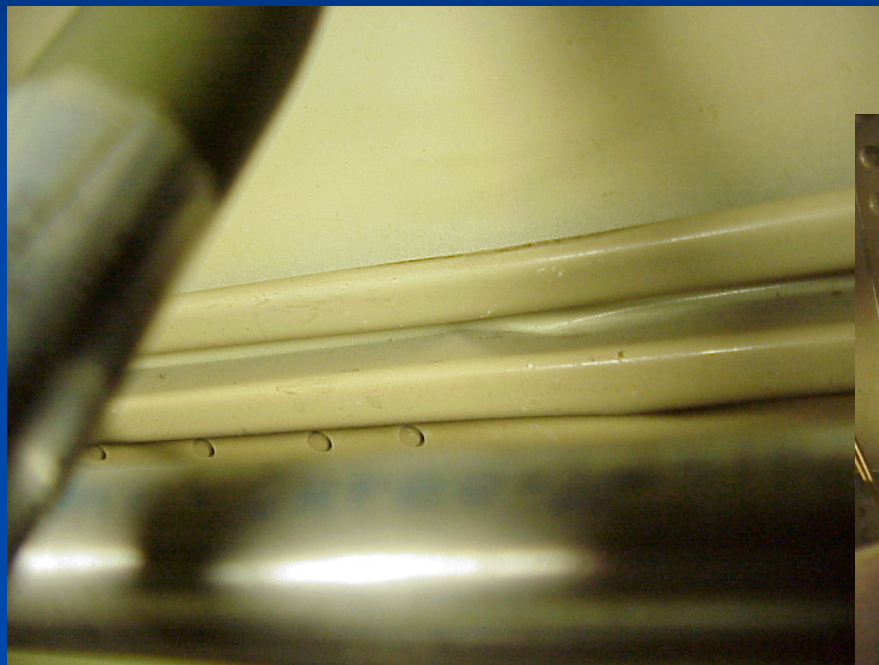
Pylon Panels debonded, warped, and seals deteriorated





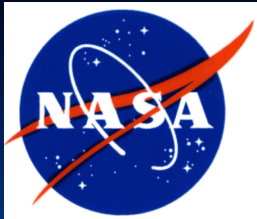
# Damage

N2NA Pylon  
Overheat Mishap



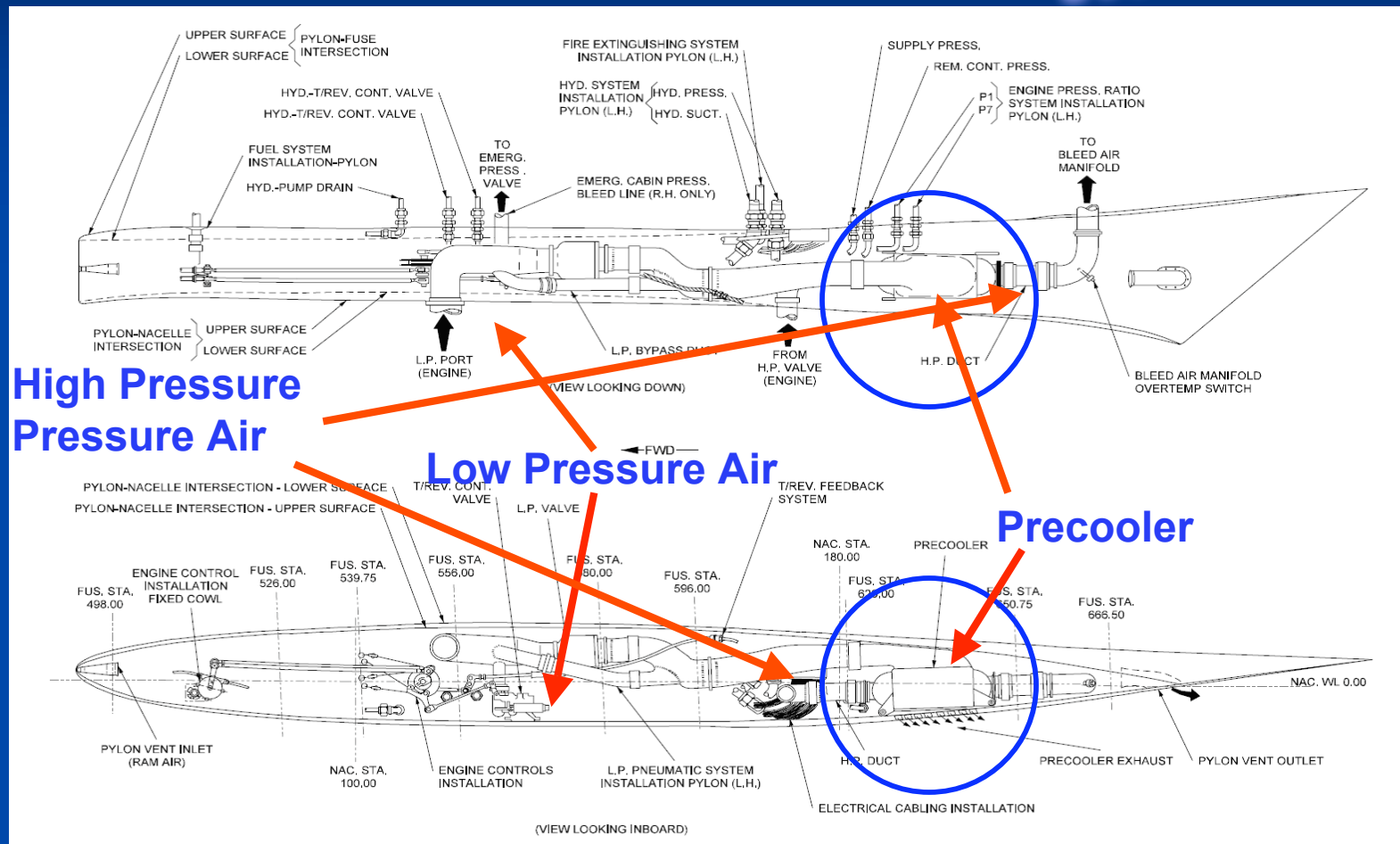
FS 610- Stringers #9 and #10 Right Damaged

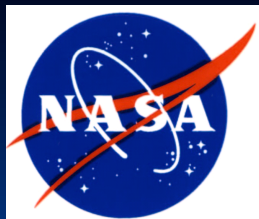




# Engine Pylon Area

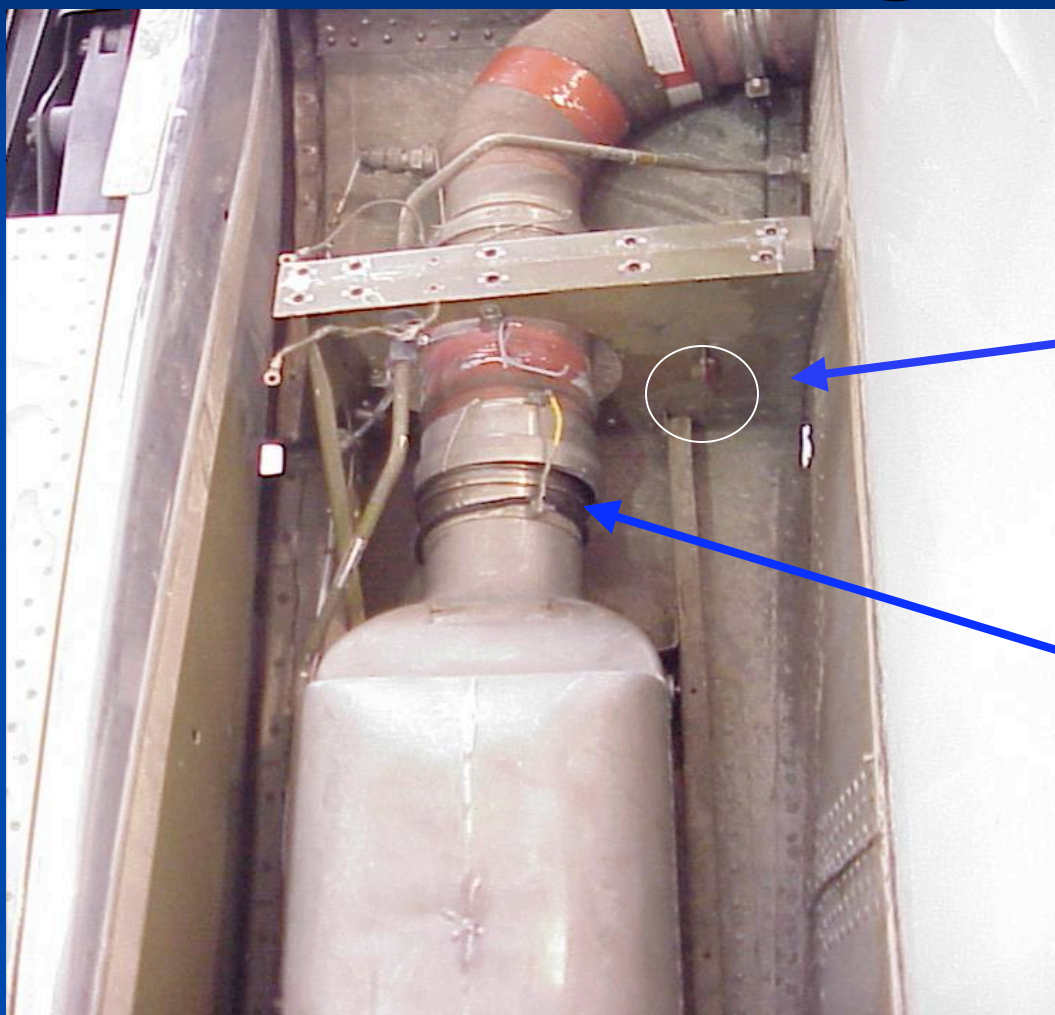
## N2NA Pylon Overheat Mishap





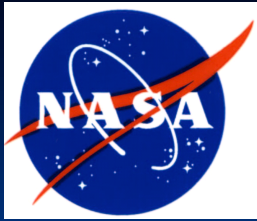
# Damage

N2NA Pylon  
Overheat Mishap



Pylon Hot Sensor

Right Precooler  
HP Exhaust Coupling

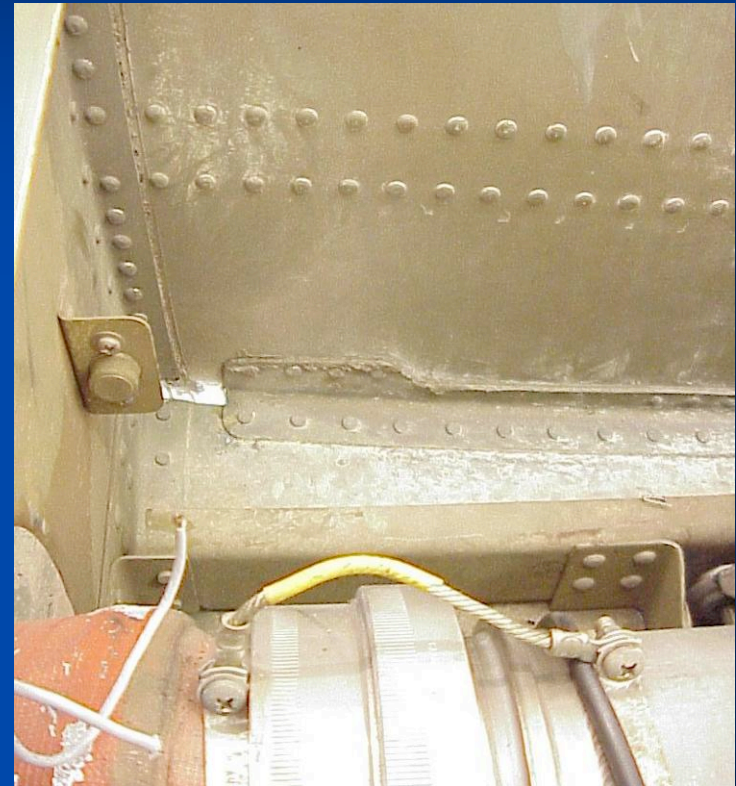


# Damage

N2NA Pylon  
Overheat Mishap

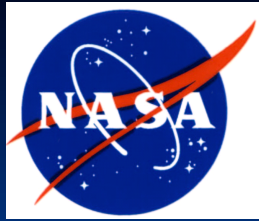


Coupling and O-ring displaced



Pylon Hot Light Sensor  
Wires Broken

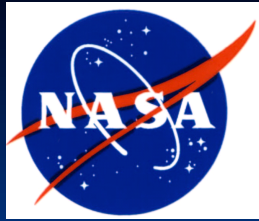




## N2NA Pylon Overheat Mishap

### Bottom Line

- \$605K in damage to fuselage structure and pylon panels
- Proximate Causes –
  - Precooler coupling installed without retaining ring allowed 400 deg F/40 psi air to damage structure and disable primary warning system (SPF)
  - Wiring to the pylon hot warning system temperature sensor broke, disabling the system and preventing the primary aircrew warning of the bleed air leak condition.
- Root Causes – None
  - Did not uncover any systemic organizational factors

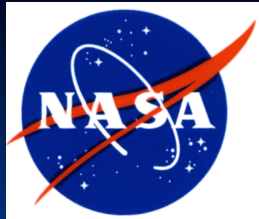


## N2NA Pylon Overheat Mishap

# Bottom Line

- Significant Intermediate Causes
  - The maintenance and inspection technical data (Computerized Maintenance Program (CMP) task card, Illustrated Parts Catalogue (IPC), and Aircraft Maintenance Manual) associated with the precooler installation did not identify, depict, and establish the importance of the retaining ring to the HPE coupling and its viability.
  - The lack of restraint and protection of the pylon hot warning system temperature sensor wiring allowed the wiring to break under the conditions of a bleed air leak from a disconnected precooler HPE coupling before the warning system could activate.
- Other factors contributed





# Causal Tree Legend

N2NA Pylon  
Overheat Mishap



“And” Logic Gate



Event



“Or” Logic Gate



Root Cause (Bold Border)



Subtree Designation



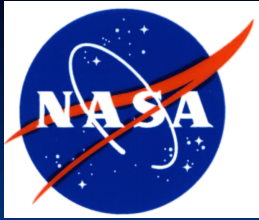
Condition



Contributing Factor (Dashed Border)



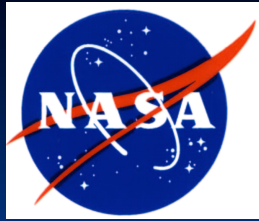
When attached below an event or condition indicates that the span of control to obtain or resolve that data is limited



## Maintenance Documentation

N2NA Pylon  
Overheat Mishap

- CMP –Computerized Maintenance Program:
  - Series of tasks in checklist form for maintaining the aircraft.
  - Maintained by aircraft manufacturer
  - Electronic database – printed out for each assigned task



## Maintenance Documentation

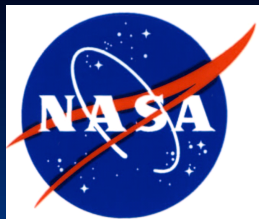
N2NA Pylon  
Overheat Mishap

### ■ Illustrated Part Catalogue

- Diagrams of all subsystems and aircraft
- Created by aircraft manufacturer
- Online reference that can be printed out
- Maintained by aircraft manufacturer

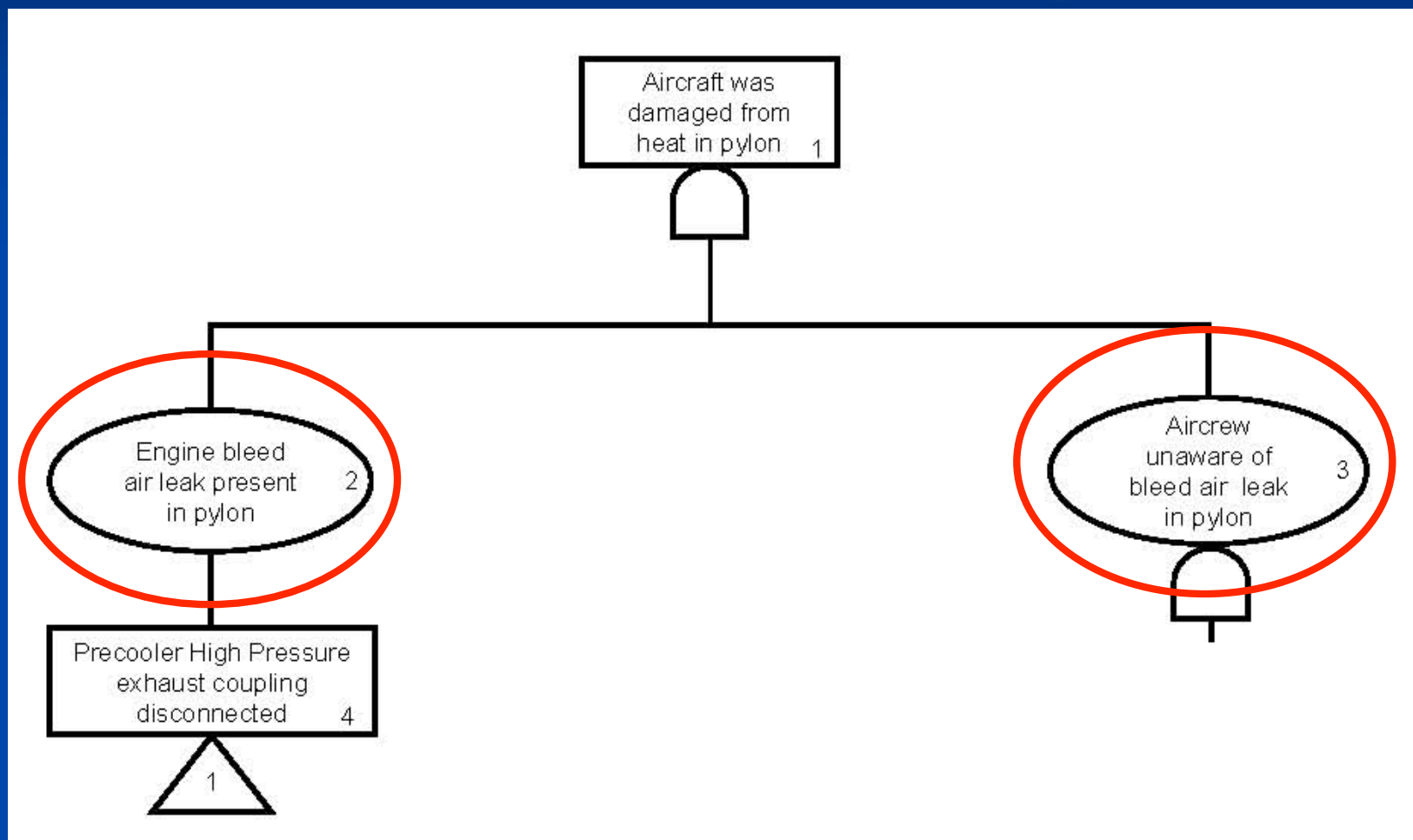
### ■ Maintenance Manual

- Description of subsystems and their function
- Online reference that can be printed out
- Maintained by aircraft manufacturer

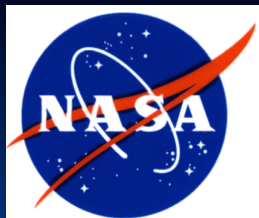


## Causal Tree - Top Level

N2NA Pylon  
Overheat Mishap

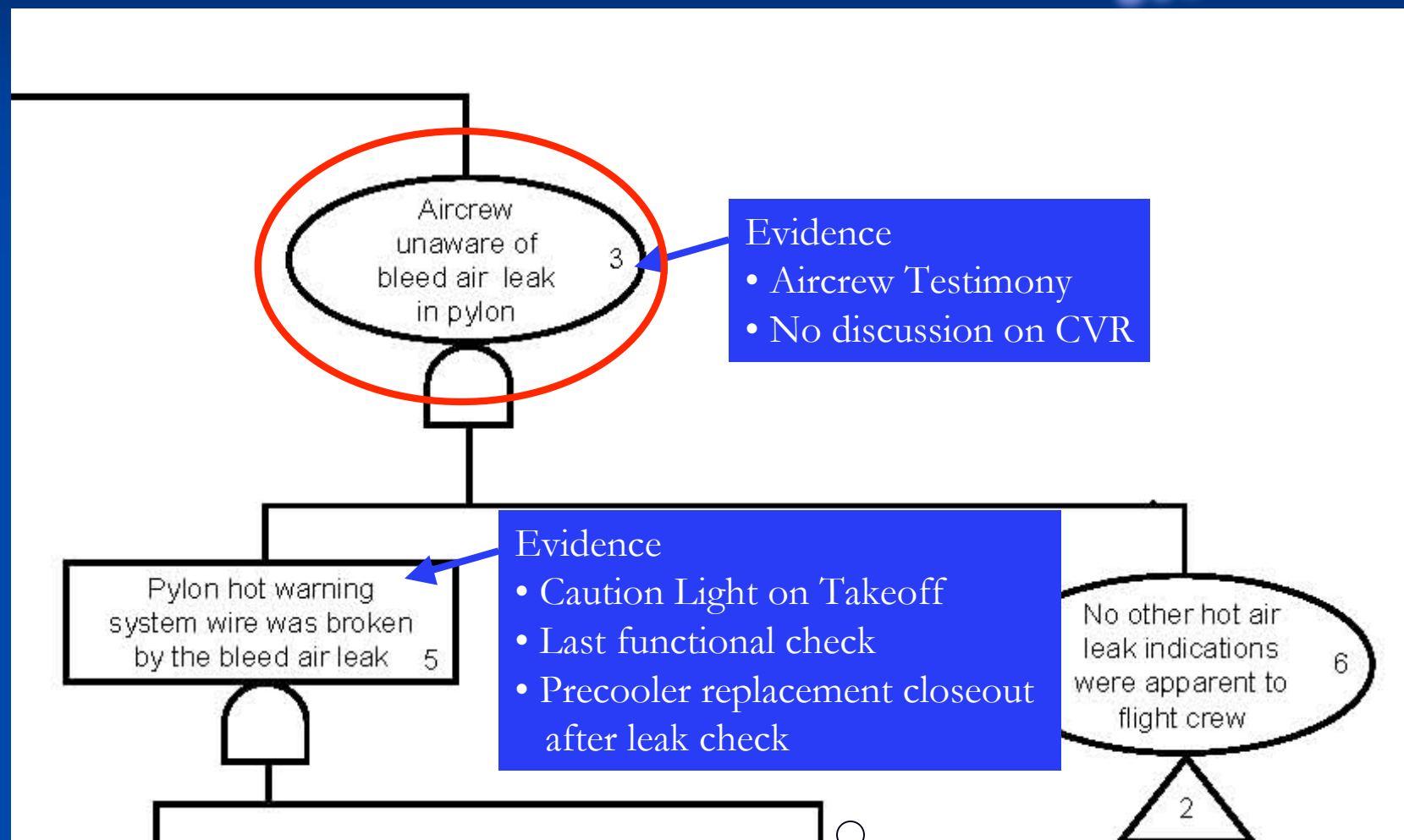


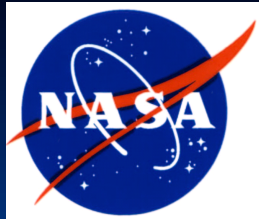




## Aircrew Unaware of pylon leak

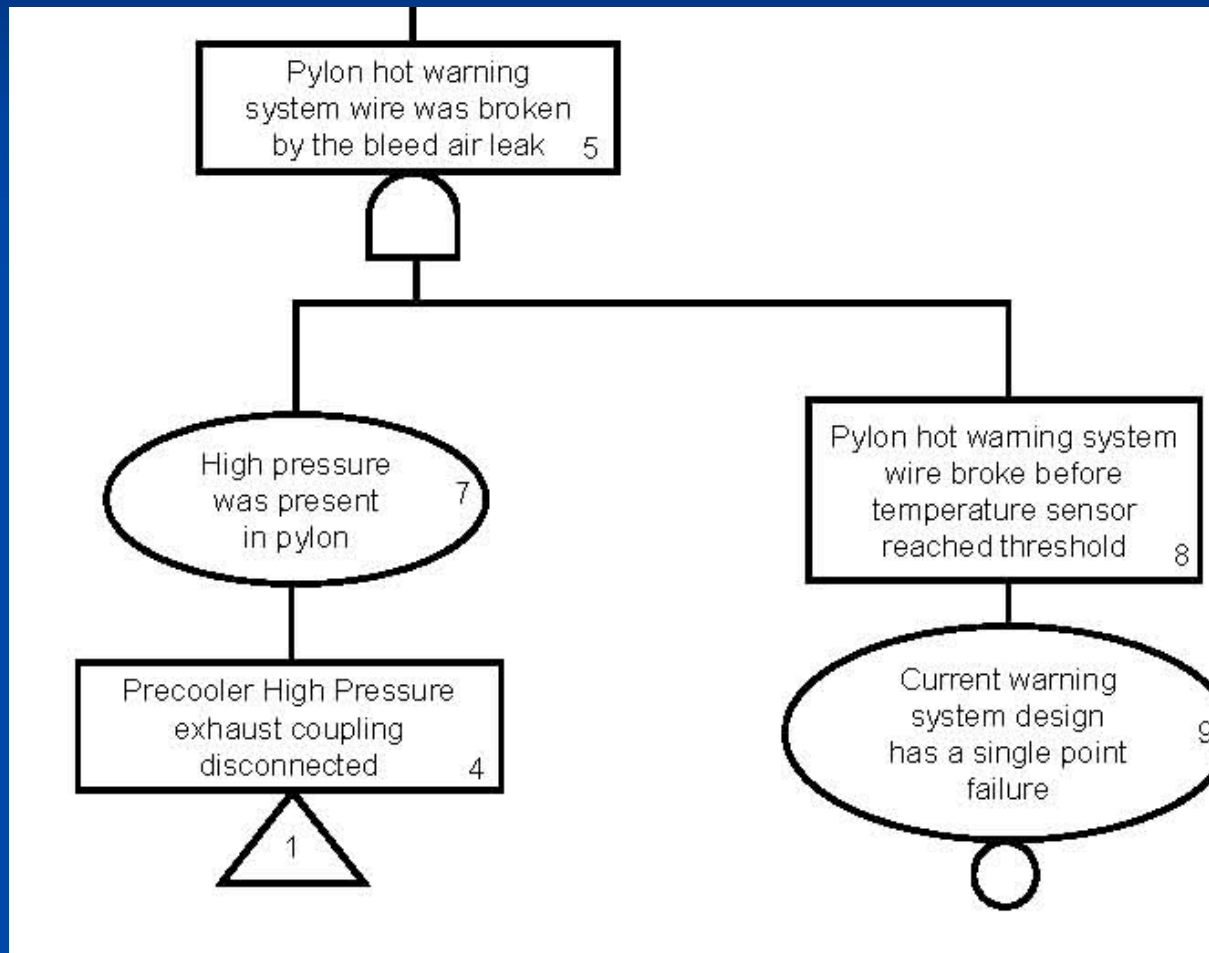
## N2NA Pylon Overheat Mishap

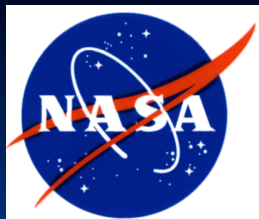




## Pylon Hot Sensor Wire Breaks

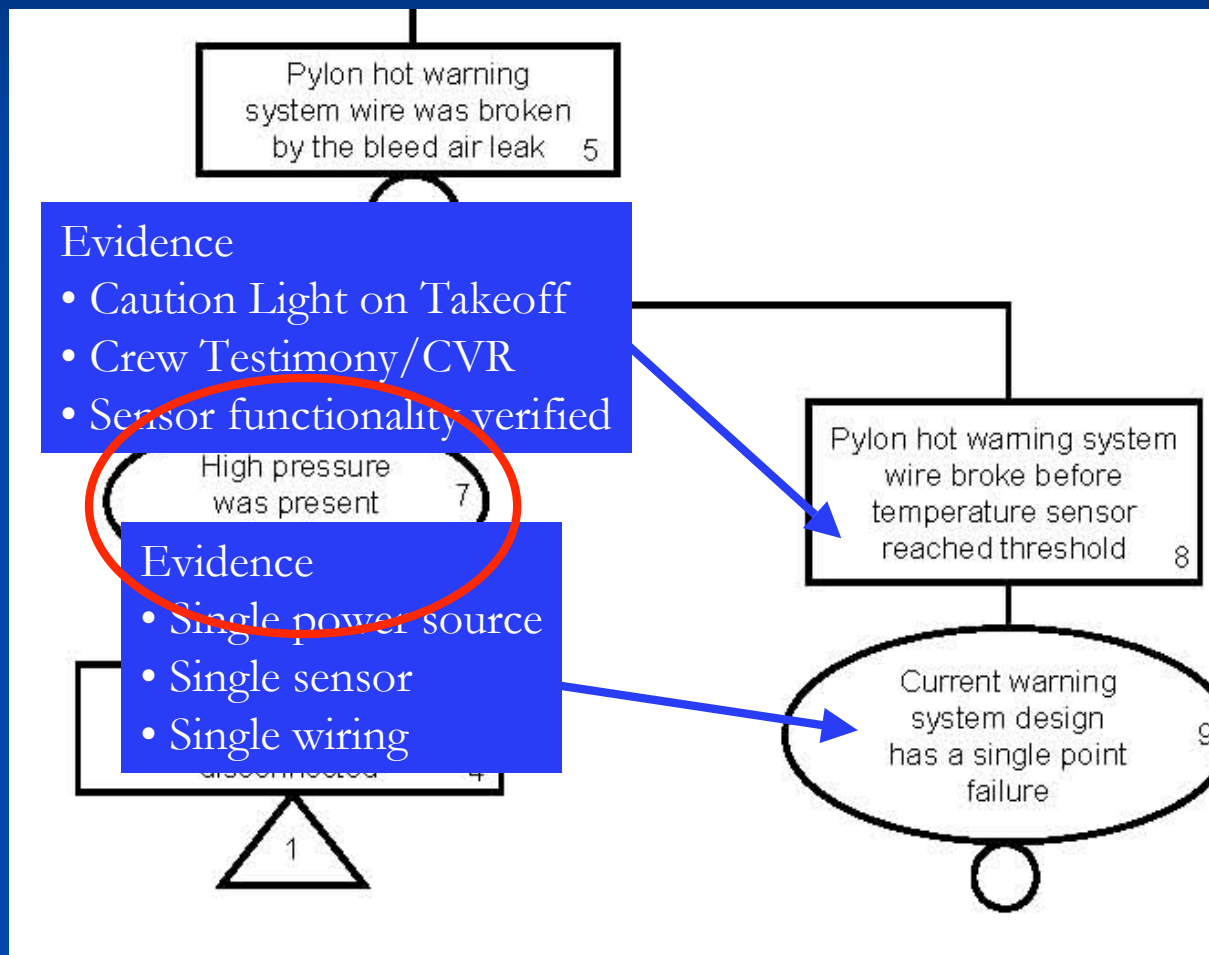
N2NA Pylon  
Overheat Mishap

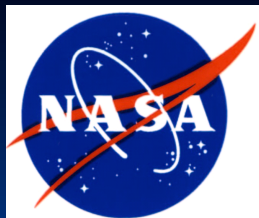




## Pylon Hot Sensor Wire Breaks

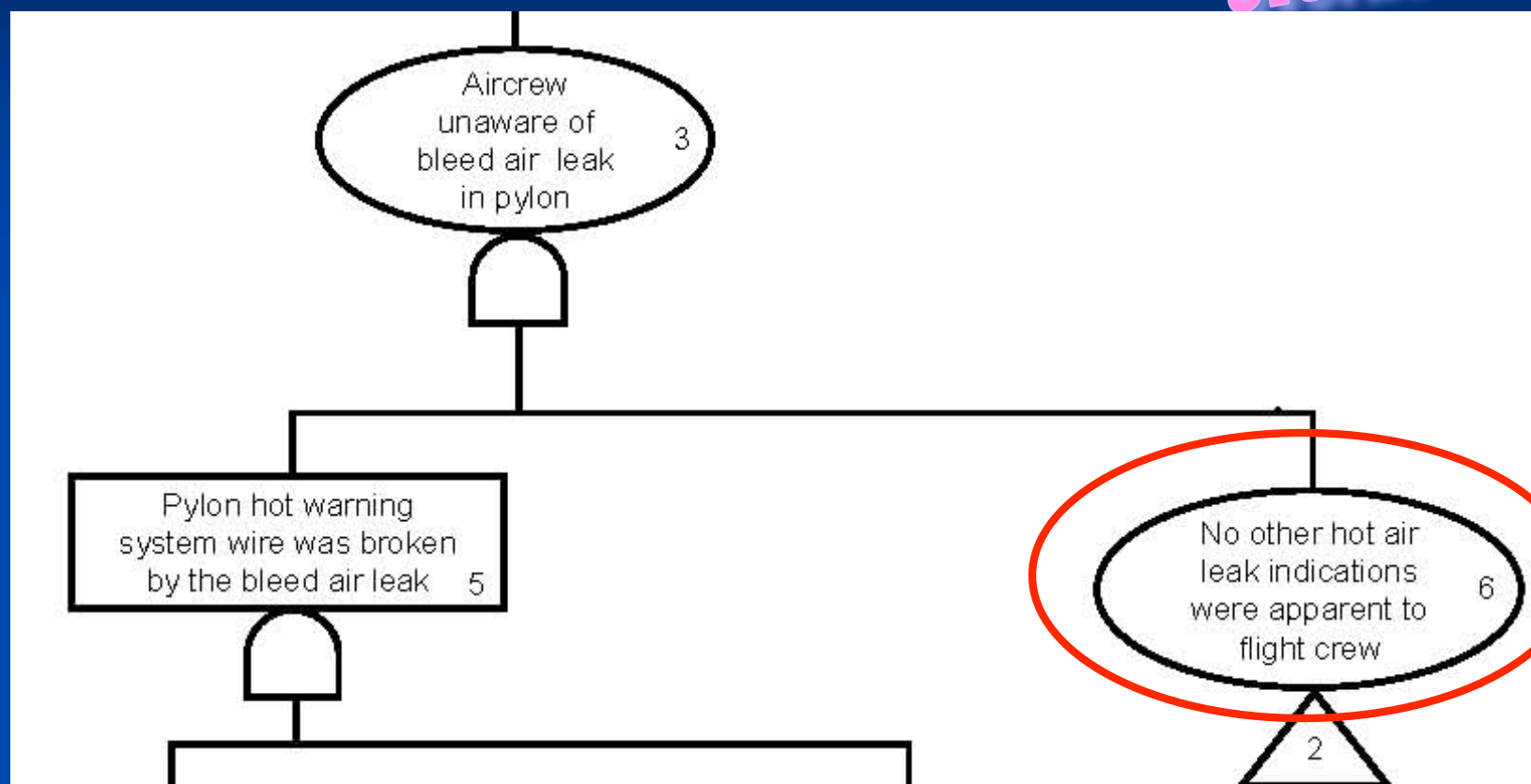
N2NA Pylon  
Overheat Mishap



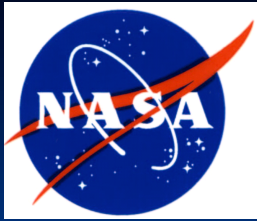


## No Other Indications of Leak

N2NA Pylon  
Overheat Mishap

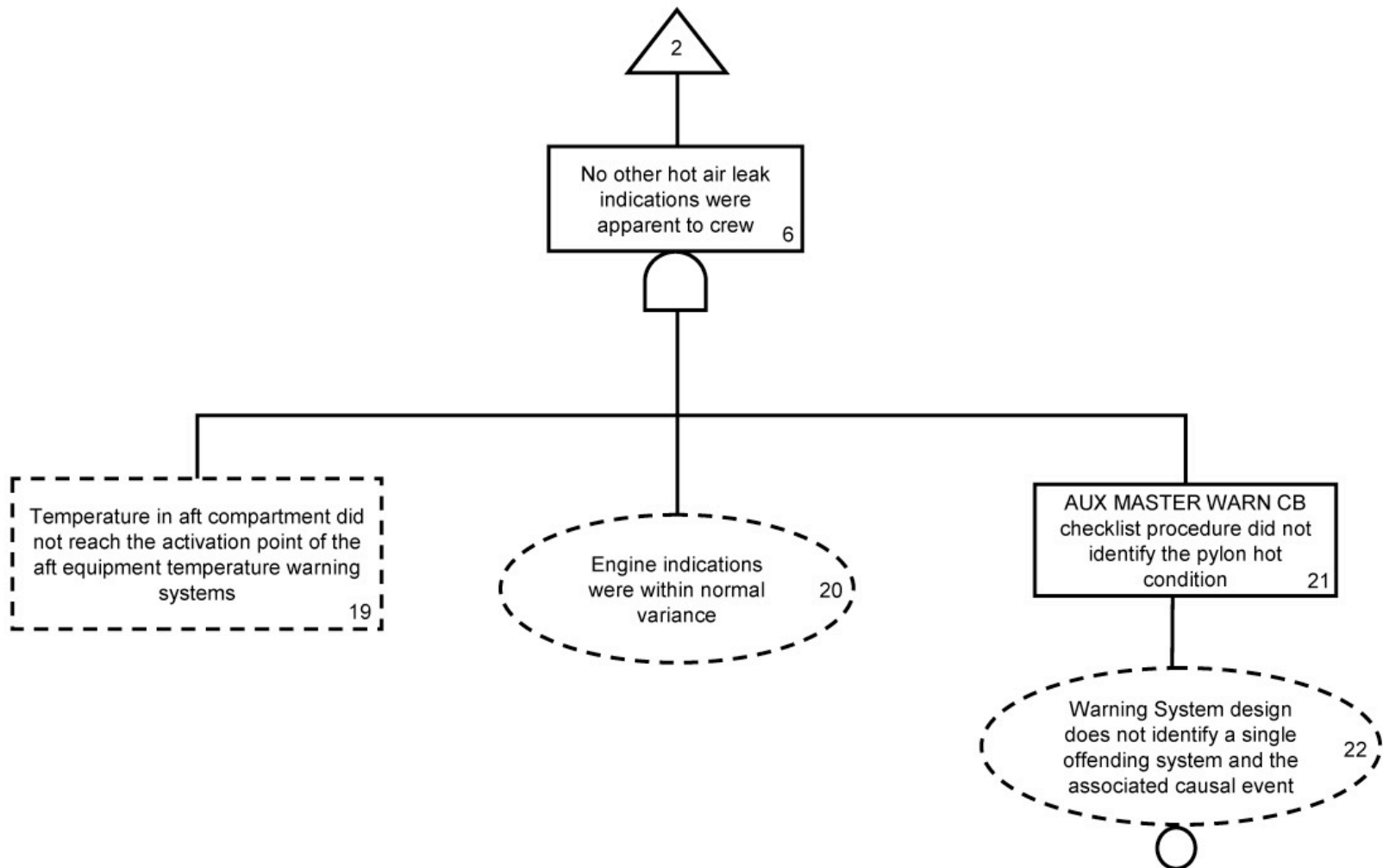


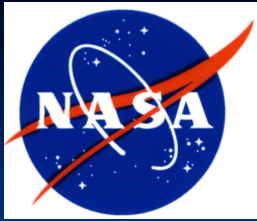




## No Other Indications of Leak

N2NA Pylon  
overheat Mishap





## No Other Indications of Leak

## N2NA Pylon Overheat Mishap

### Evidence

- No significant engine parameter differences reported
- Bleed air manifold pressure reported normal
- FDR had no engine data

### Evidence

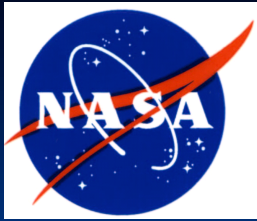
- Multiple warning sensors did not activate (200 deg F)
- Fire Bottles did not discharge (185 – 200 deg F)
- Insulation material melting point
  - Limited to manifold entrance
  - Temp 220 deg F

Temperature in aft compartment did not reach the activation point of the aft equipment temperature warning systems 19

Engine indications were within normal variance 20

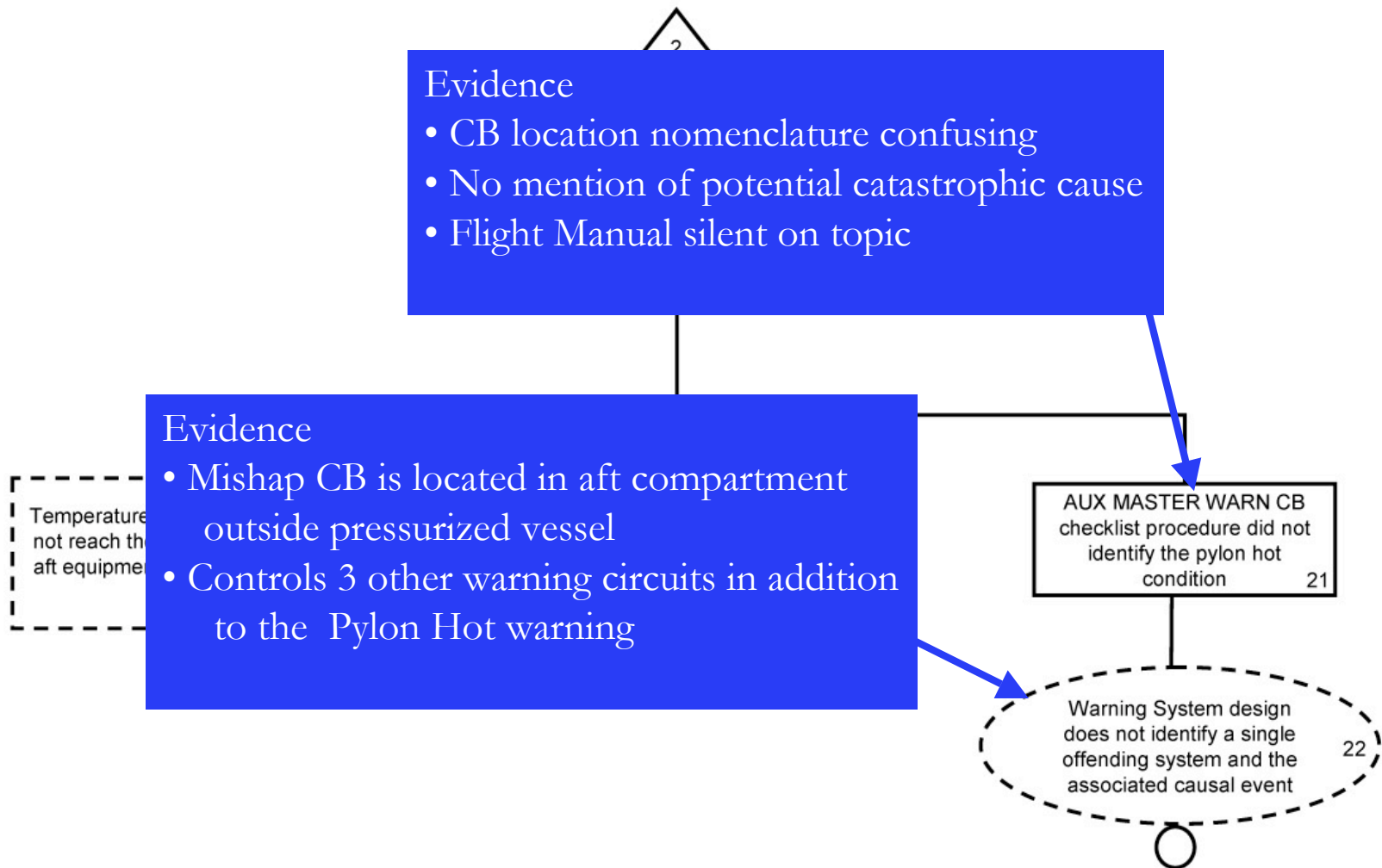
AUX MASTER WARN CB checklist procedure did not identify the pylon hot condition 21

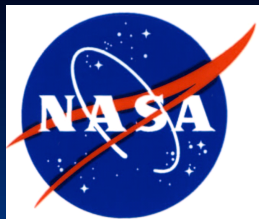
Warning System design does not identify a single offending system and the associated causal event 22



## No Other Indications of Leak

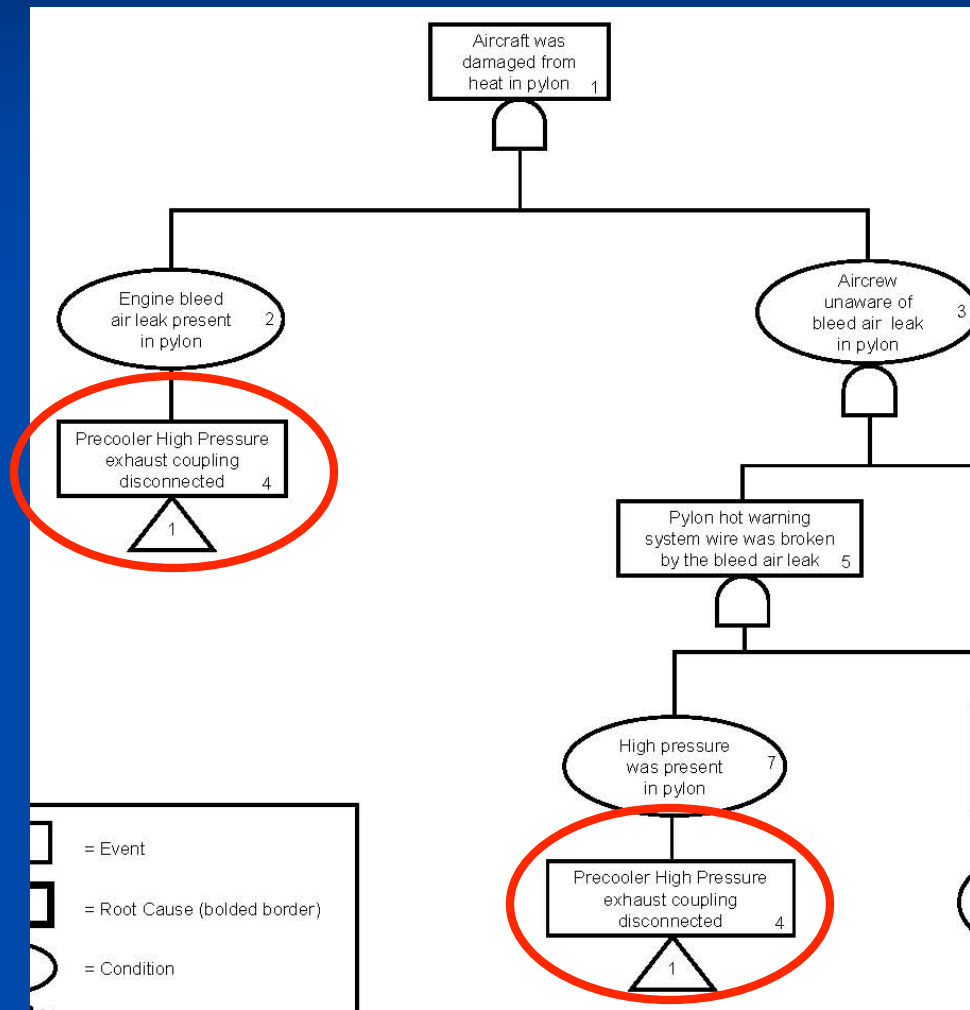
## N2NA Pylon overheat Mishap



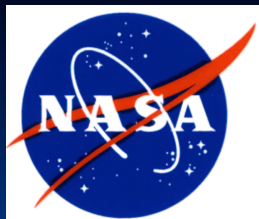


# Precooler HPE Coupling Disconnects

N2NA Pylon  
Overheat Mishap







## HPE Coupling Disconnects

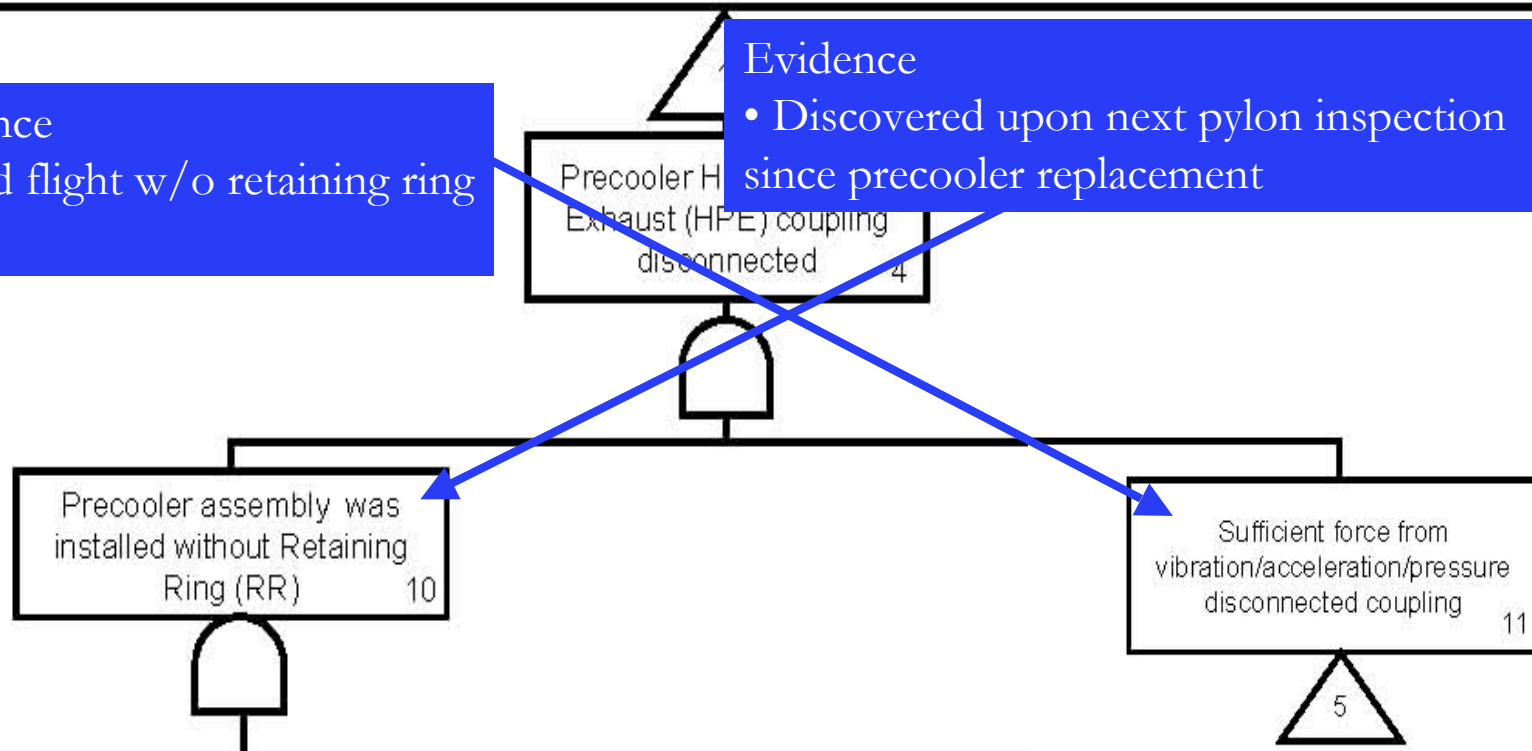
## N2NA Pylon Overheat Mishap

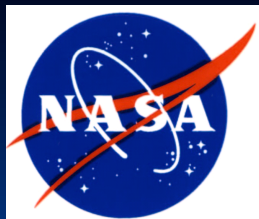
### Evidence

- Third flight w/o retaining ring

### Evidence

- Discovered upon next pylon inspection since precooling replacement



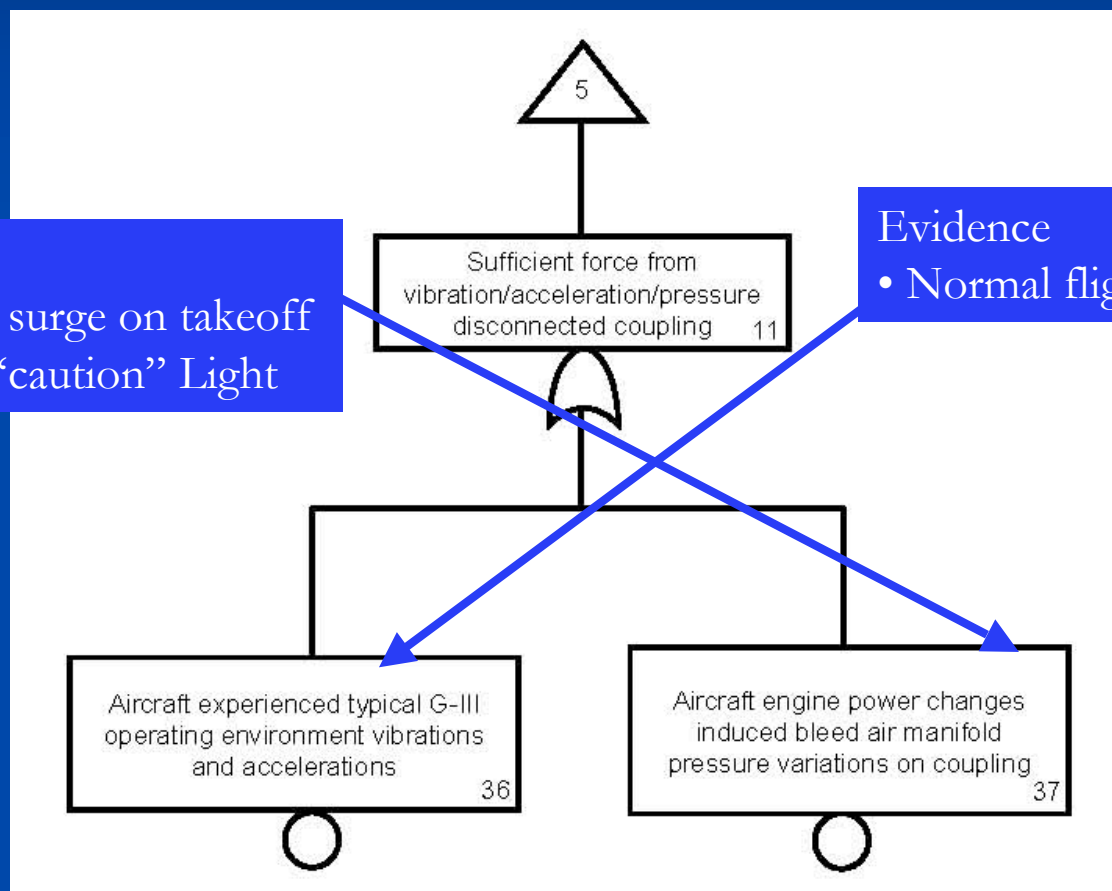


## Sufficient Force/Vibration

## N2NA Pylon Overheat Mishap

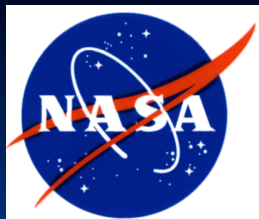
### Evidence

- Initial engine surge on takeoff aligned with “caution” Light



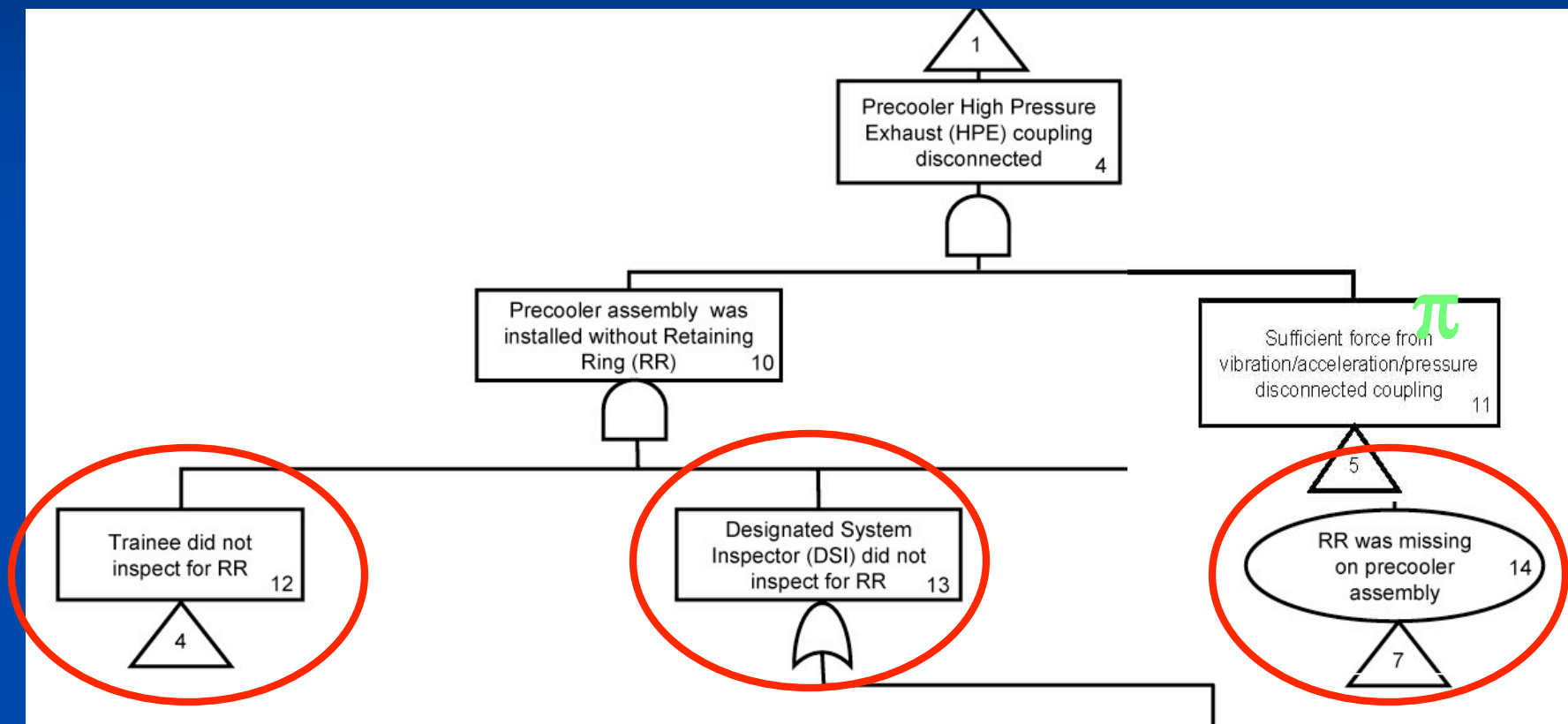
### Evidence

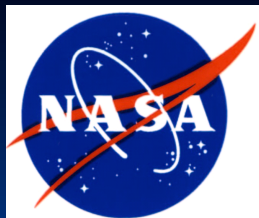
- Normal flight envelope (FDR)



# RR Missing on Precooler

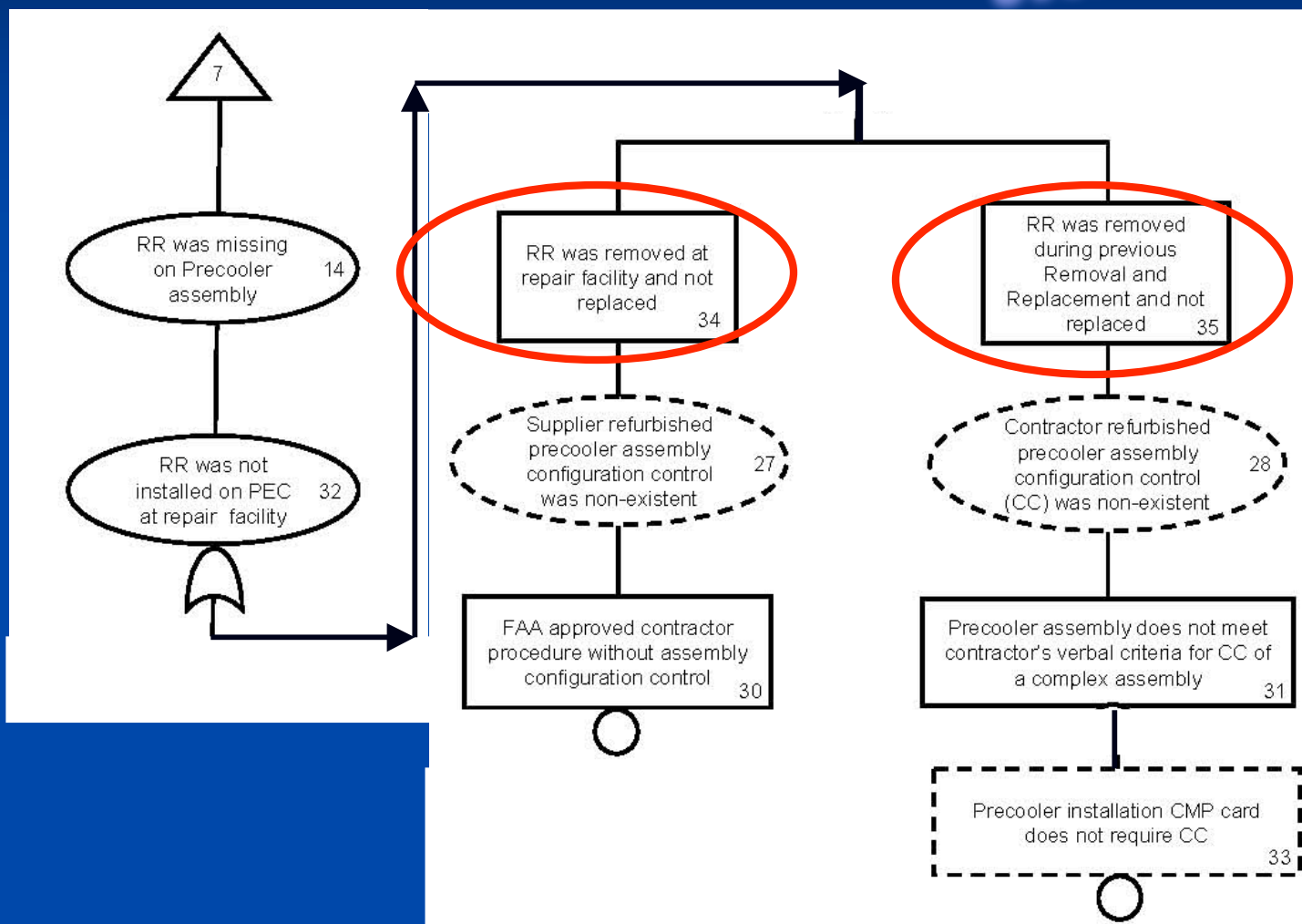
N2NA Pylon  
Overheat Mishap



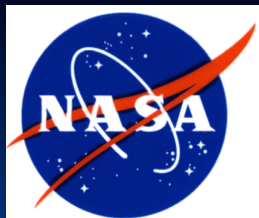


## RR Missing – Poor Config Control

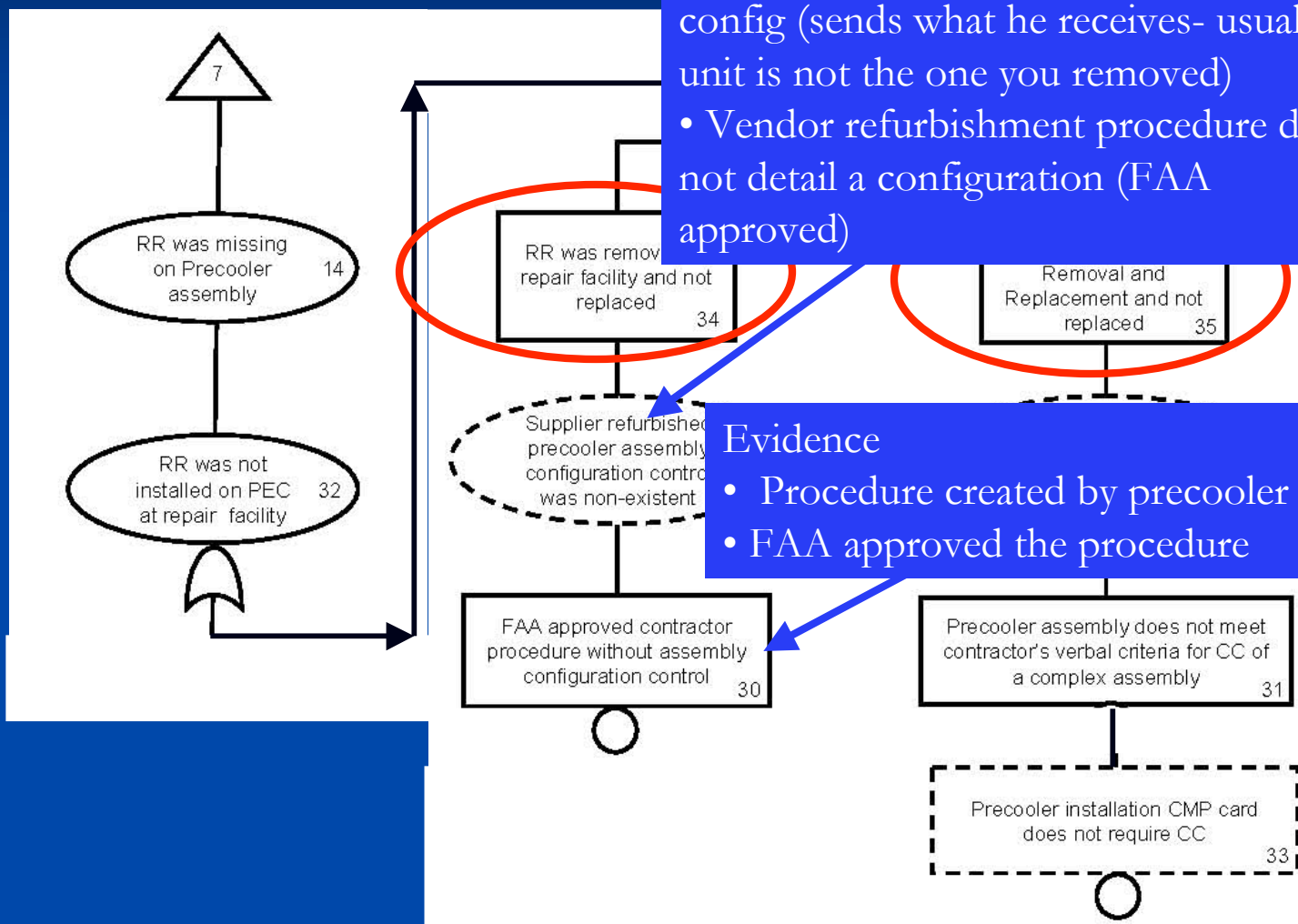
N2NA Pylon  
Overheat Mishap

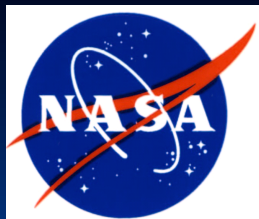






## RR Missing – Poor Conf





## RR Missing – Poor Configuration Control

N2NA Pylon  
Overheat Mishap

Evidence:

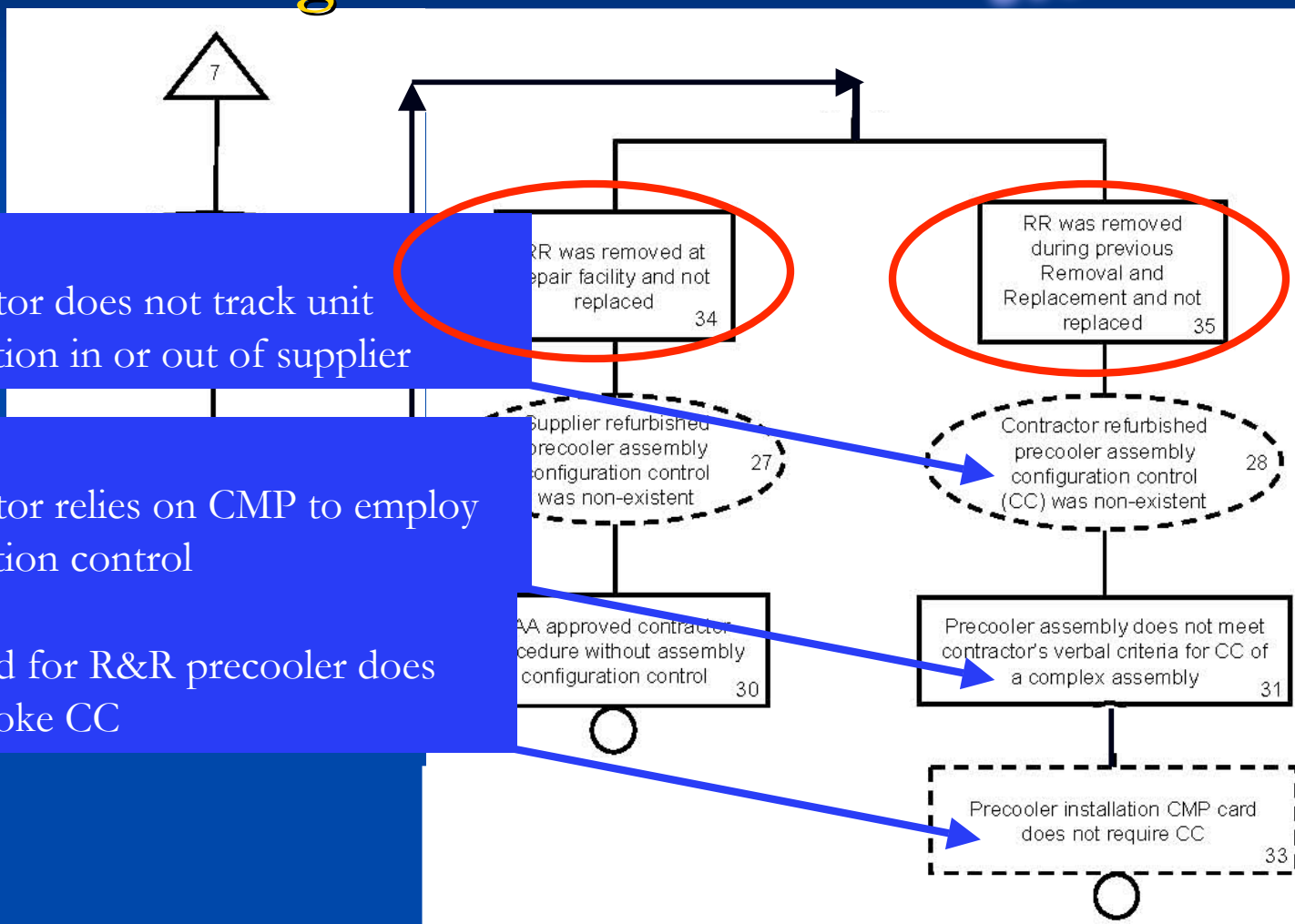
- Contractor does not track unit configuration in or out of supplier

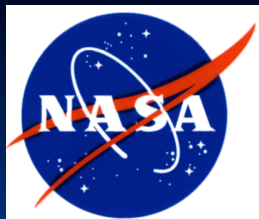
Evidence:

- Contractor relies on CMP to employ configuration control

Evidence:

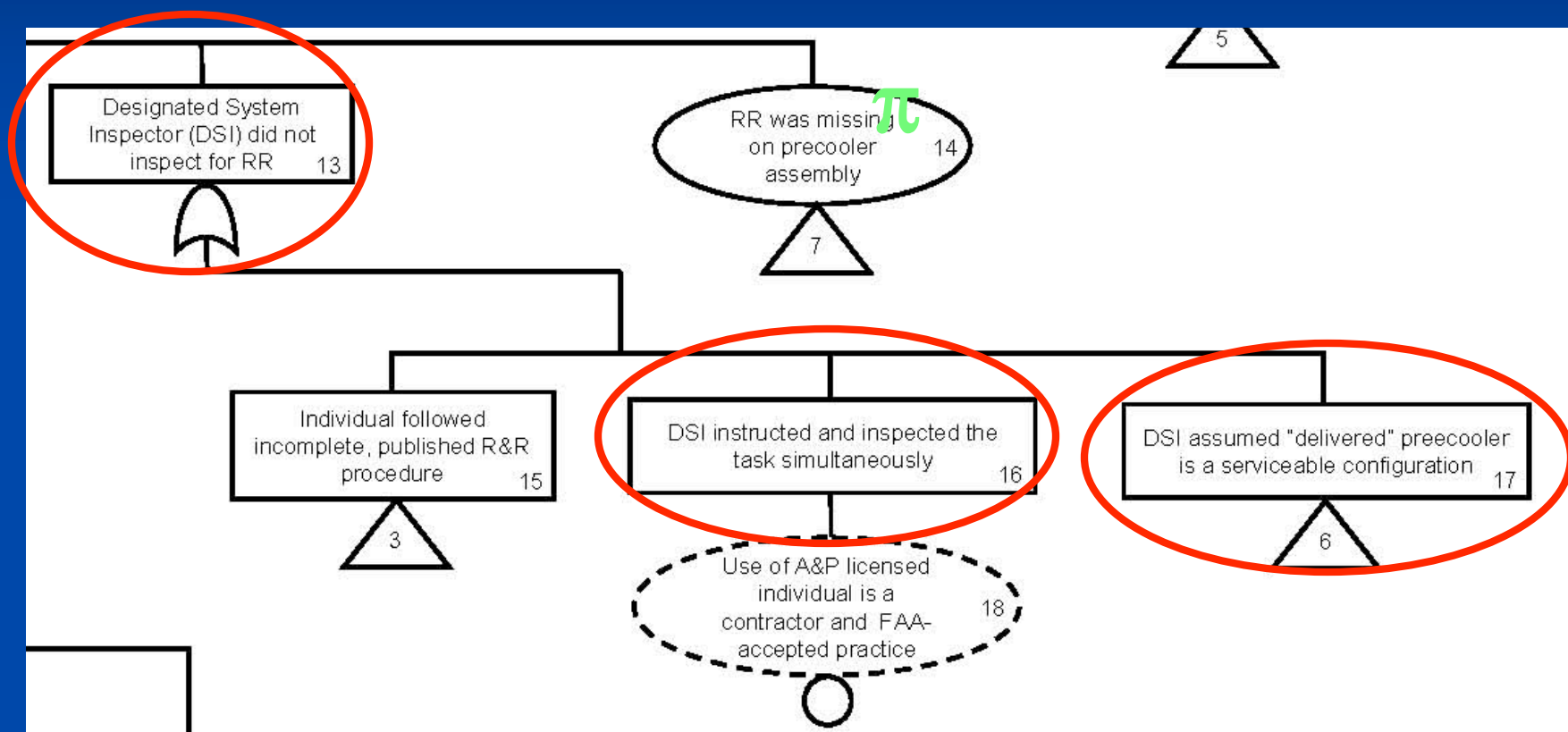
- CMP card for R&R precoolers does not invoke CC

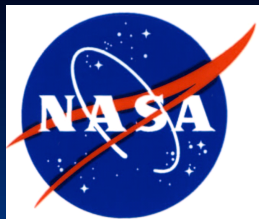




## DSI Did Not Inspect for RR

N2NA Pylon  
Overheat Mishap





## DSI Instructed and Inspected Task Simultaneously

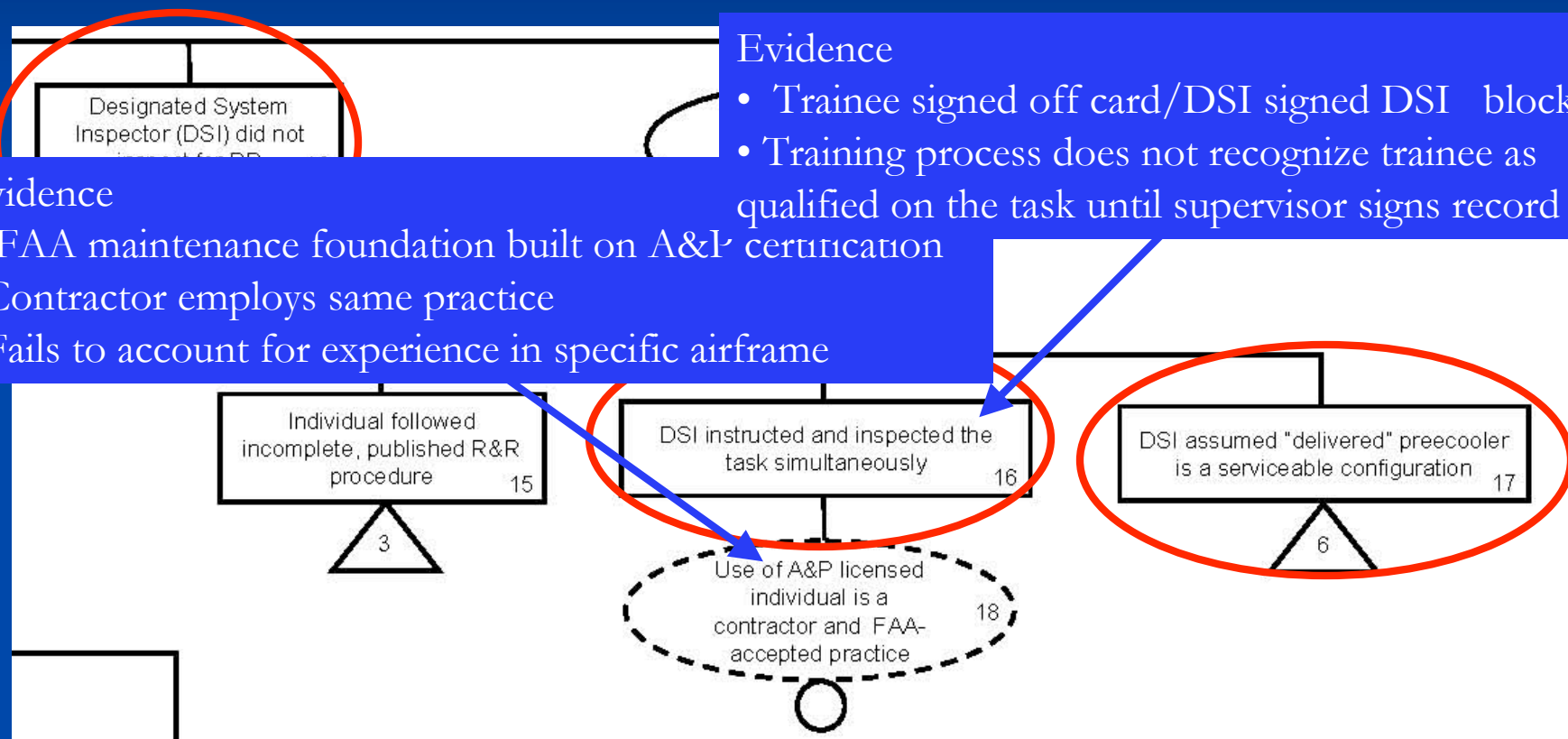
N2NA Pylon  
Overheat Mishap

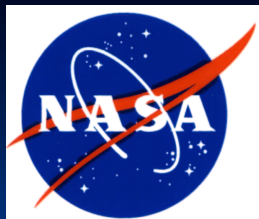
### Evidence

- Trainee signed off card/DSI signed DSI block
- Training process does not recognize trainee as qualified on the task until supervisor signs record

### Evidence

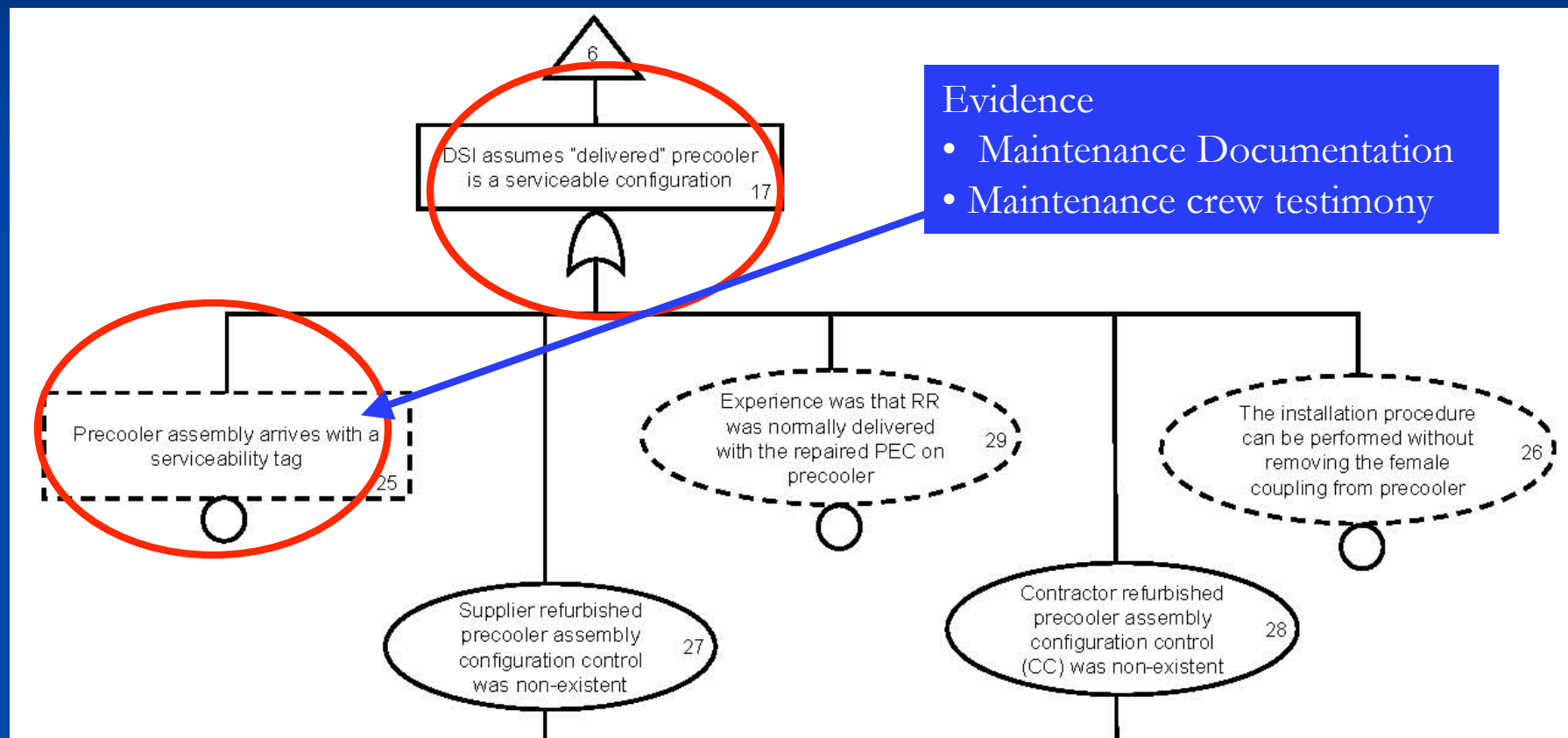
- FAA maintenance foundation built on A&P certification
- Contractor employs same practice
- Fails to account for experience in specific airframe



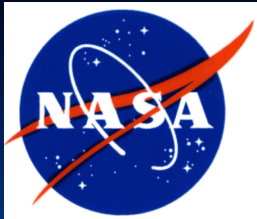


## DSI Assumes Serviceable Precooler

N2NA Pylon  
Overheat Mishap





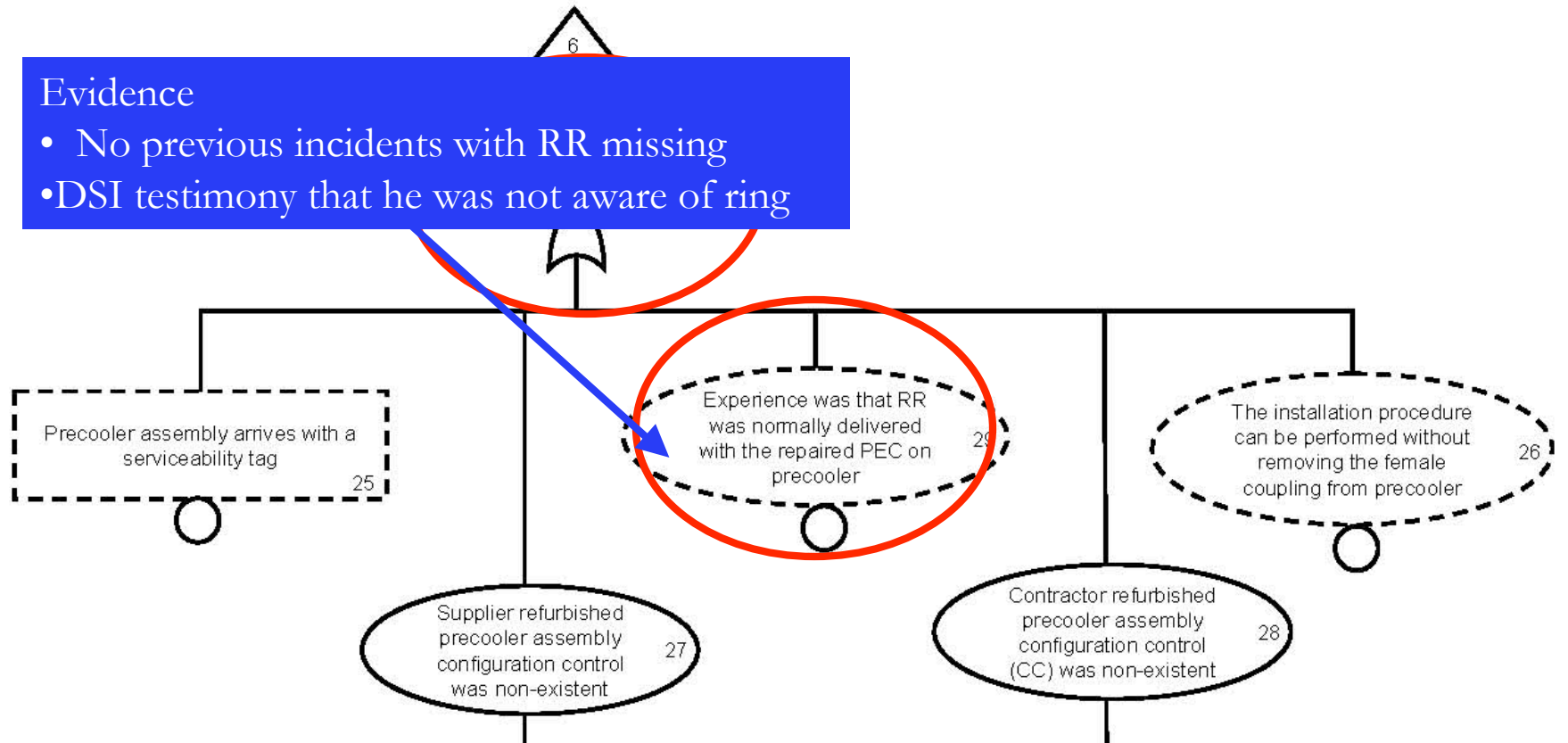


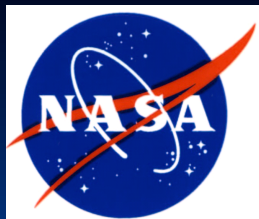
## DSI Assumes Serviceable Precooler

N2NA Pylon  
Overheat Mishap

### Evidence

- No previous incidents with RR missing
- DSI testimony that he was not aware of ring



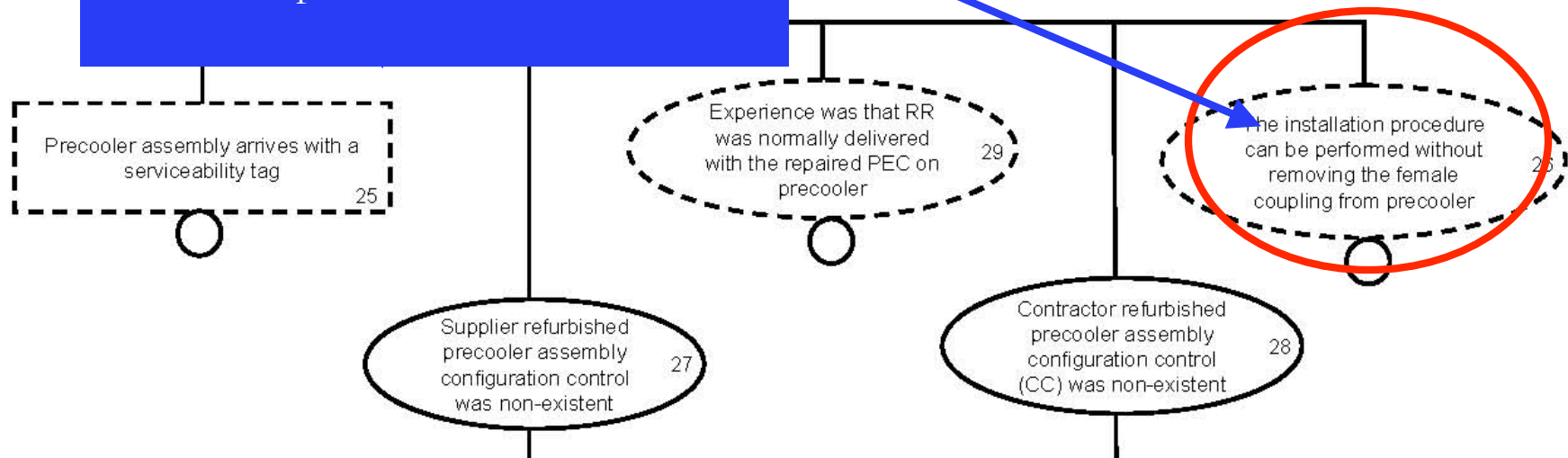


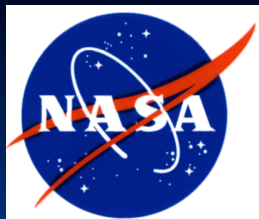
## DSI Assumes Serviceable Precooler

N2NA Pylon  
Overheat Mishap

### Evidence:

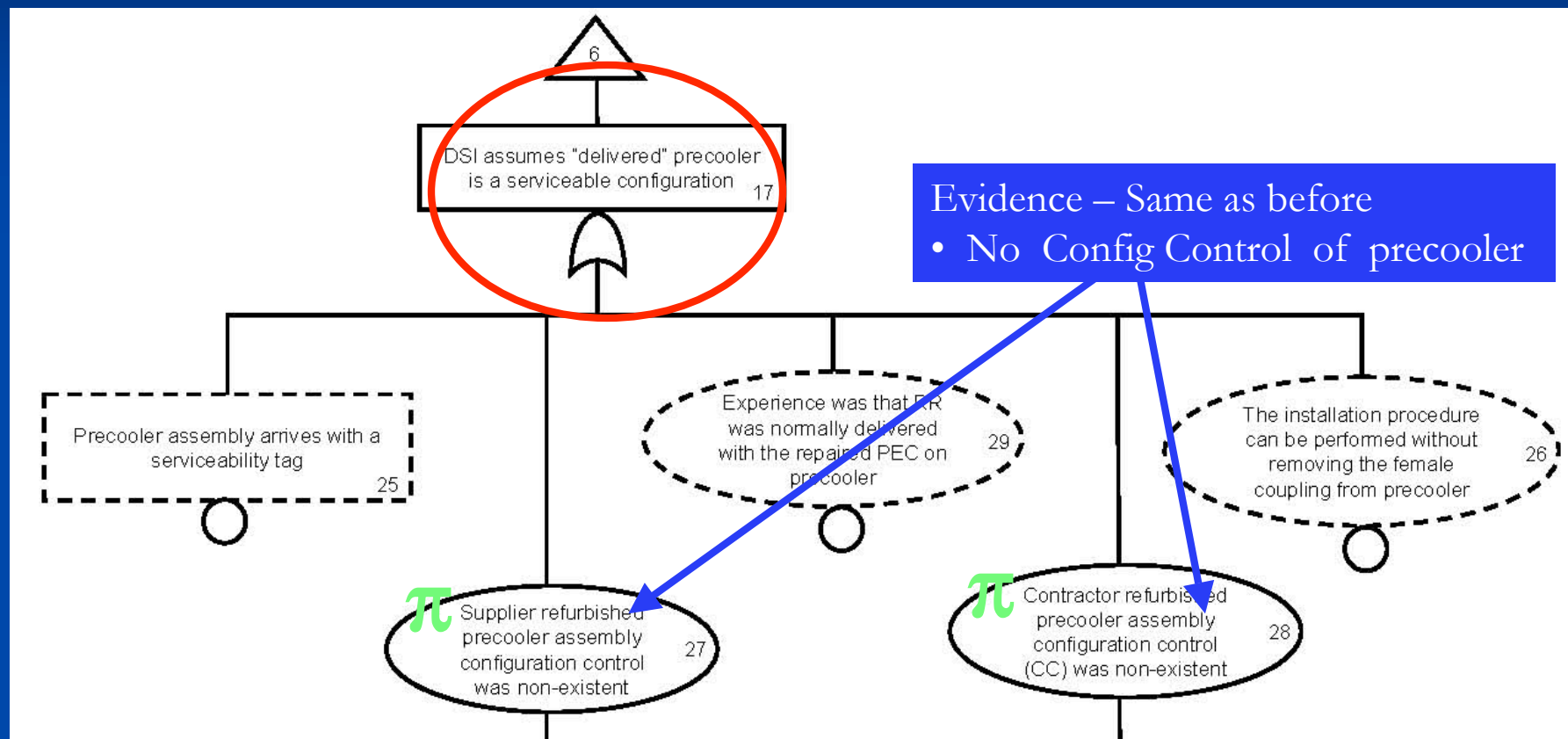
- O-rings can be installed without removing female portion of coupling
- Coupling halves join after precooler and duct in place

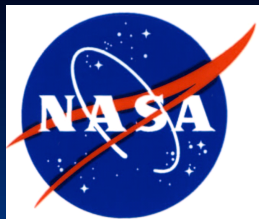




## DSI Assumes Serviceable Precooler

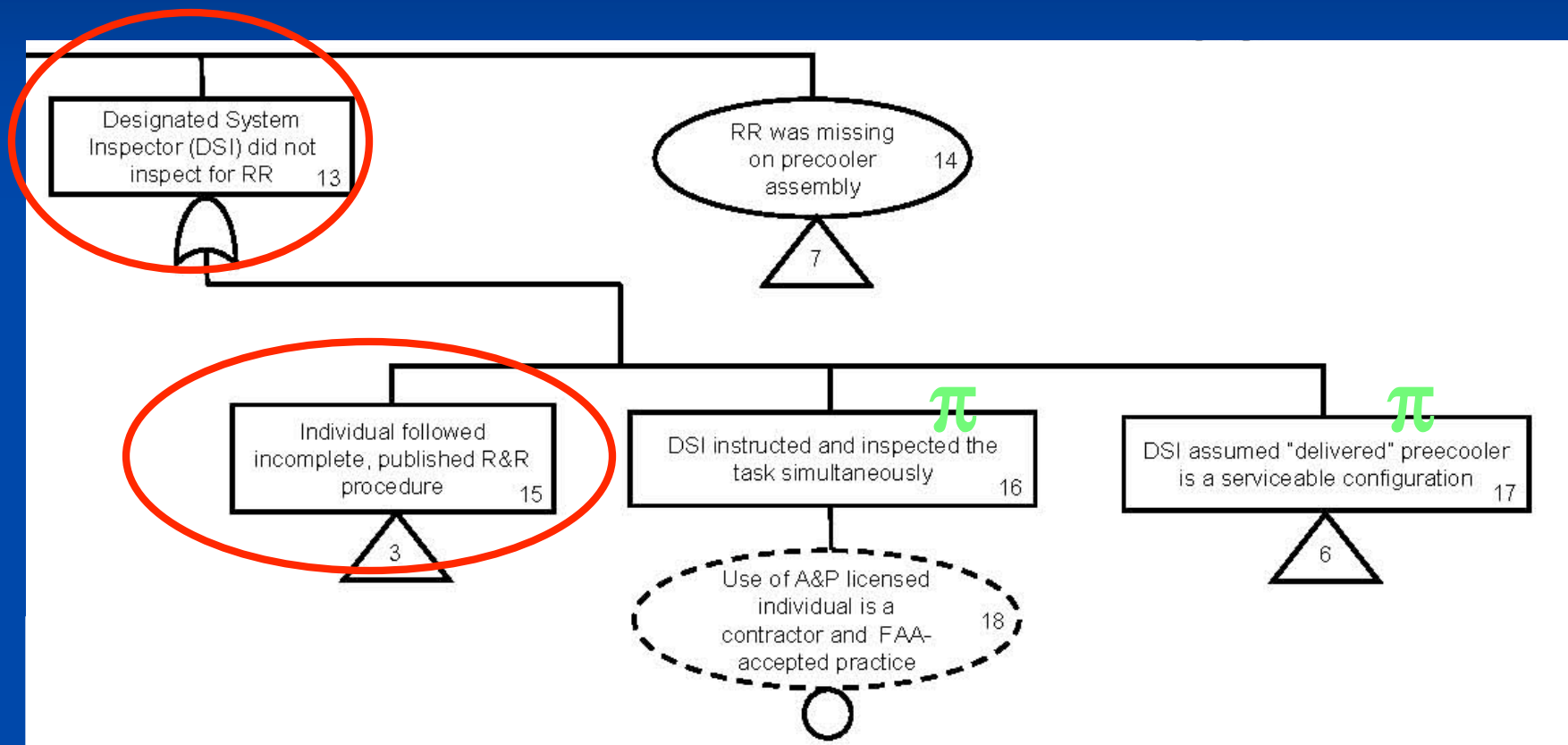
N2NA Pylon  
Overheat Mishap

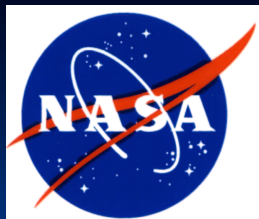




## DSI Followed Incomplete Procedure

N2NA Pylon  
Overheat Mishap





# Incomplete Precooler R&R Procedure

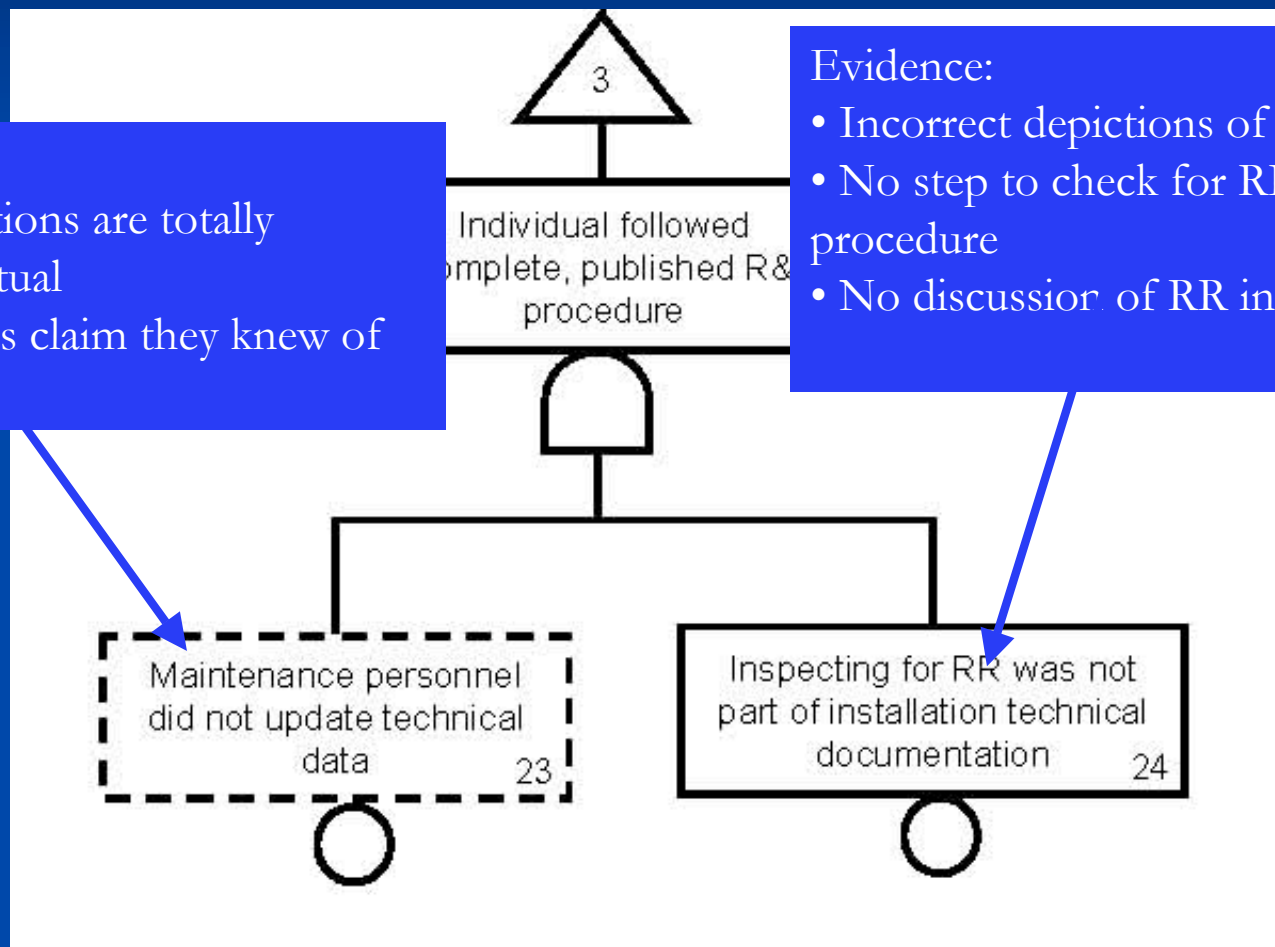
N2NA Pylon  
Overheat Mishap

## Evidence:

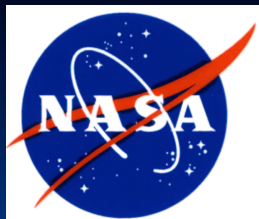
- Coupling depictions are totally different from actual
- Some technicians claim they knew of RR

## Evidence:

- Incorrect depictions of coupling
- No step to check for RR in CMP procedure
- No discussion of RR in IPC

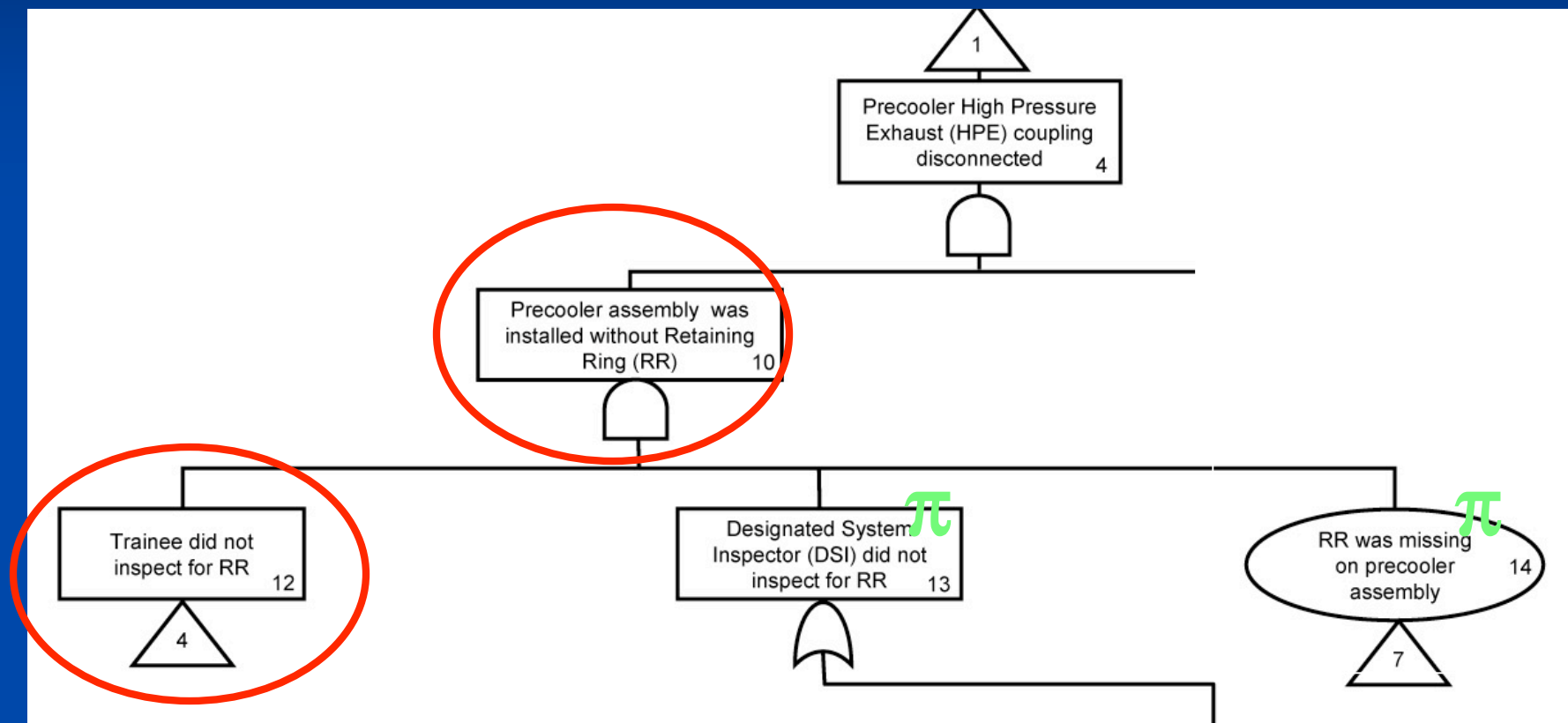


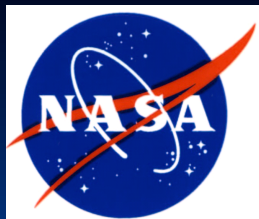




## Trainee Did Not Inspect for RR

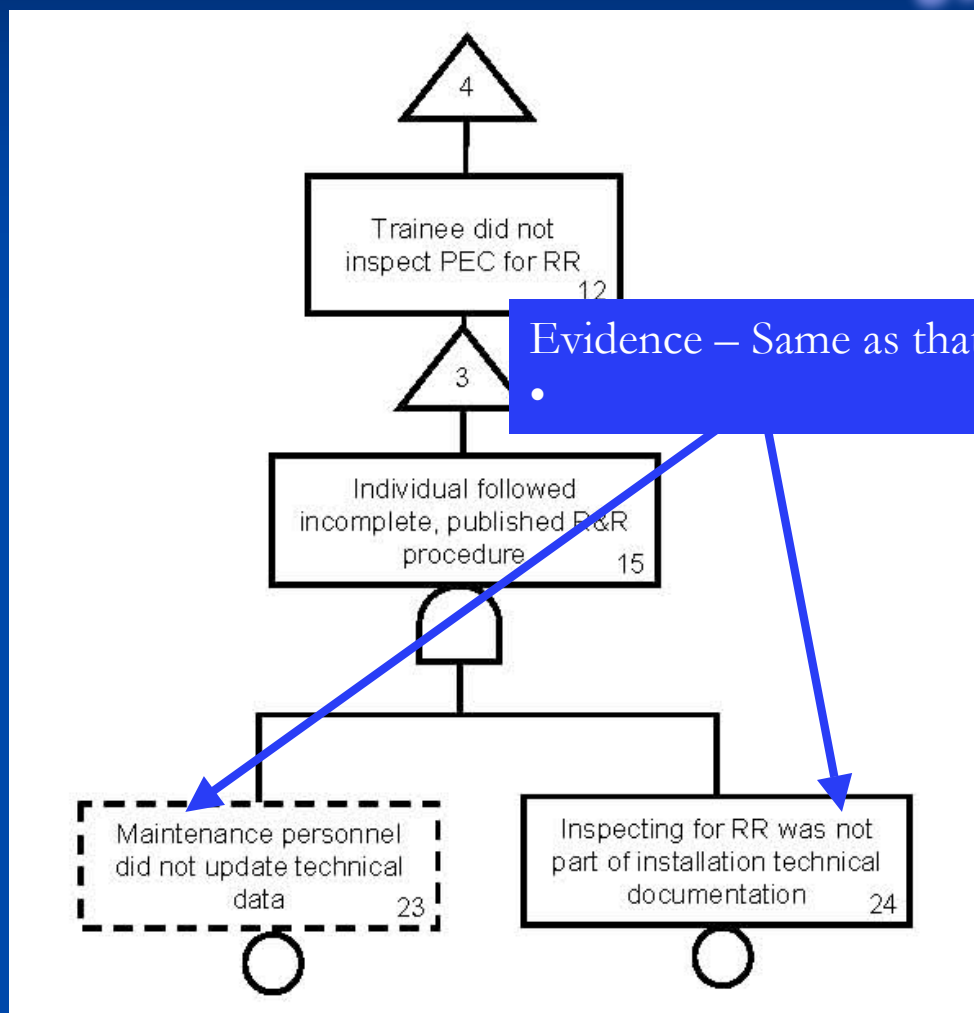
N2NA Pylon  
Overheat Mishap





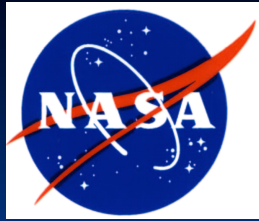
# Trainee Did Not Inspect for RR

N2NA Pylon  
Overheat Mishap



Evidence – Same as that for the DSI

-

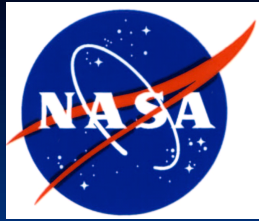


## No Organizational Factors

N2NA Pylon  
Overheat Mishap

### ■ Maintenance Training

- No real identified deficiency since task documentation was deficient
- Some technicians knew of the Retaining Ring
- All personnel were trained per standards
- Contract SOW was sufficiently clear and complete
- Maintenance COM implemented SOW accurately
- Training process was followed

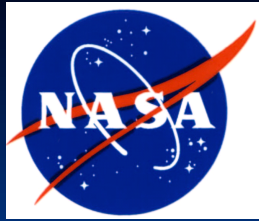


## No Organizational Factors

N2NA Pylon  
Overheat Mishap

### ■ Configuration Control

- No real identified deficiency since documentation was silent on Retaining Ring
- Contract SOW was sufficiently clear and complete
- COM shifted responsibility to lead supervisors
- Supervisors relies on CMP as the point of application—defines when CC is required.
- No requirement in CMP for precooler R&R
- No past mishaps with this factor as a cause



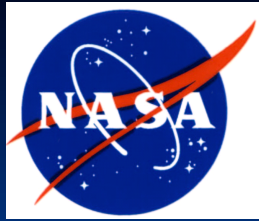
## No Organizational Factors

N2NA Pylon  
Overheat Mishap

### ■ Documentation Update

- Some Documentation does have clear inaccuracies
- Lack of knowledge mitigates some failure to update
- Process & policy is clear and reinforced
- Submissions to documentation are occurring by employees
- No past mishaps with this as a factor as a cause

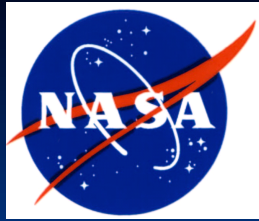




# Significant Observations

## N2NA Pylon Overheat Mishap

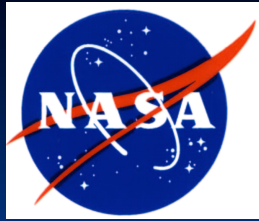
- Contractor Parts Process does not
  - Verify FAA certification for a specific part
  - Monitor vendor viability (FAA alerts)
  - Monitor specific part quality (GIDEP)
  - Mishap vendor was
    - Not listed as authorized to repair this specific part - admin mistake by FAA
    - Lost certification for a period of time (FAA alert) for oil precoolers
    - Under investigation again



## N2NA Pylon Overheat Mishap

### Significant Observations

- Aircrew local & sim training was incomplete on Aux Master Warning Circuit Breaker
- Some incidents reviewed had no investigation documentation, tough to get answers/prevents trending.



N2NA Pylon  
Overheat Mishap

## Major Recommendations

- Correct maintenance technical data and improve config control to prevent RR absence
- Redesign the Pylon Hot Warning System for the NASA fleet to improve sensor wiring integrity
- Inspect for RR just prior to installation
- Bar trainees unqualified in task from signing off work as primary technician